RAKIPOSHI, OR "DEVIL'S TAIL" MOUNTAIN 25,550 FEET HIGH IN HUNZA NAGAR.

FROM A PAINTING BY COLONEL H. C. B. TANNER.

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MEMOIR

ON THE

INDIAN SURVE

1875–1890;

1995
STOCK VERIFIED

BY

CHARLES E. D. BLACK.

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ILLUSTRATIONS.

FRONTISPIECE.—RAKIPOSHI MOUNTAIN (25,550 feet high), in HUNZA-NAGAR. *To face Title page.*

MAP OF INDIA - - - - - - *To face page* 1.

PREFACE.

THIS work was suggested by Mr. Clements R. Markham's "Memoir on the Indian Surveys," in which the geographical and other kindred operations carried out in India from the date of the British occupation were reviewed in a most picturesque and masterly manner. In 1878 a second edition of Mr. Markham's work was published, in which the narrative was brought up to 1875, and in some cases for a year or so later. For the last fifteen years I have been accumulating notes in moments of leisure, with a view to the publication of a volume which might serve as a continuation to that by Mr. Markham, and the kind support given to the project by the Secretary of State for India and the Viceroy has now enabled me to present the work in a more or less complete shape. From unavoidable circumstances the arrangement of matter is not identical with that adopted by Mr. Markham, but I believe I have conformed to it sufficiently to make reference easy, and wherever the source of information is not specially mentioned, it may be assumed that it will be found in the official Annual Report for the particular year.

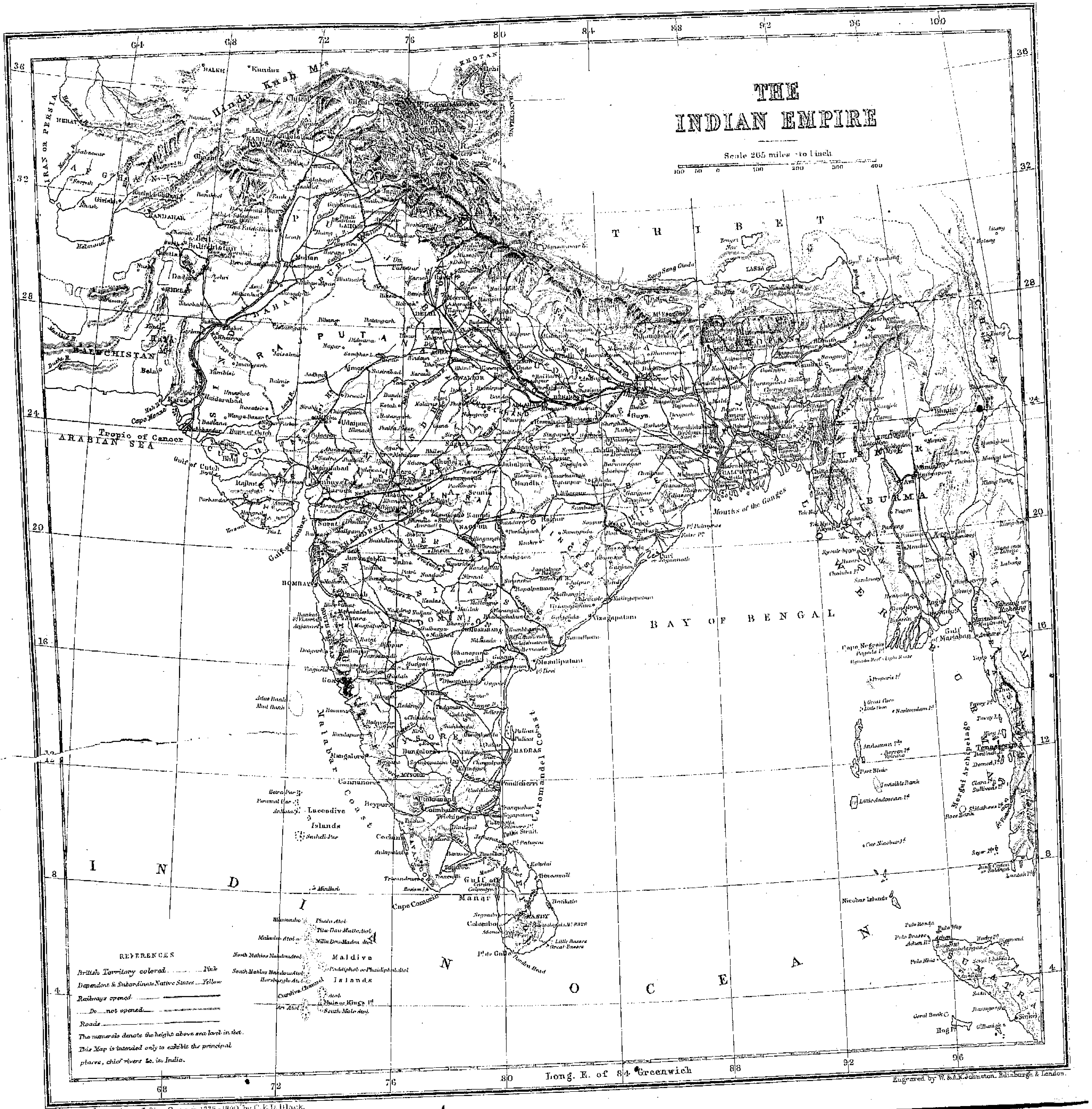
I have to express my sincere acknowledgments to those friends who have been good enough to read through the proofs and favour me with numerous suggestions, of which I have gladly availed myself. To General J. T. Walker, R.E., C.B., F.R.S., &c., formerly Surveyor-General of India, I am indebted for his careful revision of the Trigonometrical, Geodetic, and other chapters. Colonel H. R. Thuillier, R.E., the present Surveyor-General of India,

has also supplied much useful additional matter in Chapter XI. Mr. W. T. Blanford, F.R.S., has furnished me with several valuable comments on the Geological Section; Mr. H. F. Blanford, F.R.S., kindly revised the Meteorology; Sir W. W. Hunter, K.C.S.I., C.I.E., suggested some improvements in the brief chapter on the Statistical Survey; while Commander A. D. Taylor, late I.N., and Commander A. W. Stiffe, late I.N., Colonel W. Barron, B.S.C., Colonel W. J. Heaviside, R.E., Mr. E. Roberts, F.R.A.S., and Mr. T. Cushing, F.R.A.S., have been obliging enough to give similar aid in respect of the chapters dealing with Marine Surveys, Revenue Surveys, Geodetic Observations, Tidal and Levelling Observations, and the Supply of Scientific Instruments, respectively. Colonel J. Waterhouse, B.S.C., Major H. Raverty, and Mr. Ney Elias, C.I.E., have also given valued assistance in other ways. Last, but by no means least, Dr. Jas. Burgess, C.I.E., has shown great interest in, and supplied most useful information for the Chapter dealing with Indian Archæology, a subject in which he is an eminent and acknowledged authority.

My object has been to supply an outline sketch of the remarkable labours achieved during the last fifteen years by the chief Indian scientific departments, and to facilitate reference to the detailed records of those services. Any possible success that may have attended this effort is greatly due to the kind encouragement and co-operation shown by the above gentlemen.

CHARLES E. D. BLACK.

London, October, 1891.



Prepared for "Memoir on Indian Survey, 1875-1890" by C.E.D. Black.

I.

INDIAN MARINE SURVEYS.*

First Period, 1875–82.

The survey of the coasts of India has ever been a matter of high importance for navigators, and from the days of the old Bombay Marine and its successor, the Indian Navy, the observations of the bold and experienced seamen belonging to those services bore rich fruit in the labours recorded in the pages of the "Memoir on the Indian Surveys." The operations of these Indian officers extended to the Red Sea, the Persian Gulf, Arabian and African coasts, China Sea, and other regions far beyond the limits of India proper. But in 1862 the Indian Navy was abolished, and no arrangement was made for continuing the excellent survey work for which the service had become renowned. After a long period of inaction, a small but efficient and economical department was at length organised in 1875, under the superintendence of Commander A. D. Taylor, late I.N., a good start was made, and an encouraging record of work achieved had been shown in the pages of the first report.

In the spring of 1876 Commander Taylor started on a tour of inspection of the principal ports on the coast of Burma, where two steamers had struck some little time previously on rocks unmarked on the existing charts. Akyab, Bassein, Rangoon, Moulmein, Tavoy, Mergui, and the Pakchan river were visited, as well as the ultra-Indian ports of Kopah and Junkseylon on the Siam Coast. From this inspection, after examining the chart of Amherst, which was found most incorrect and incomplete, Commander Taylor arrived at the conclusion that no large port of British India so much required to be carefully surveyed. Navigating Lieutenant Jarrad, R.N., was accordingly despatched in the "Clyde" to execute

* The spelling of Indian proper names has been assimilated to that adopted in the *Imperial Gazetteer* of India.

the survey during the year 1876–77. The Admiralty chart of Tavoy river was also found to be very erroneous, but during a brief stay Commander Taylor was enabled to take observations and soundings which resulted in a more reliable chart being produced. At Junkseylon he met Captain A. de Richelieu, Siamese Royal Navy, commanding the gunboat "Coronation," from whom an excellent preliminary survey of that island was obtained, and published at Calcutta.*

In July Commander Taylor proceeded, with Navigating Sub-Lieutenant E. W. Petley, R.N., to False Point to report how the sum of Rs. 30,000, applied for as a loan to the Port Fund, could best be spent in the interests of the port. On this an elaborate report was submitted to Government. In the following March he was deputed to Goa with instructions to visit the harbours of Karwar and Marmagao and report on their relative merits as shelter-giving anchorages during the S.W. monsoon. On careful consideration, Commander Taylor came to the conclusion that Marmagao was superior as a natural harbour, and in some respects as regards the practicability of making improvements quite equal to Karwar. Two officers, Nav. Lieutenant Jarrad, R.N., and Mr. Falle, were sent to survey Madras roadstead, and a careful sectional survey of the part of the roadstead and beach abreast of the native town was commenced by them and continued by Lieutenants Hammond and Pascoe on the scale of 600 feet to 1 inch.

Lieutenant Jarrad's next work was to connect, astronomically, Diamond Island, Rangoon, and Amherst Pagoda, the three principal stations in the Gulf of Martaban essential to the reproduction of a new chart of that locality. An elaborate sectionally sounded double elephant sheet survey of Moulmein river approaches was excellently carried out, comprising 105 square miles of water closely examined, and 36 miles of coast trigonometrically laid down. An important correction of the true bearing of Double Island lighthouse from Amherst point was obtained by Lieutenant Jarrad, who discovered the former to be 1½ miles westward of its true position, notwithstanding that it had already been shifted a distance of 4½ miles to the eastward of the positions shown on the Admiralty charts. His next step was to commence a

* An interesting article by Captain De Richelieu on Salang island or Junkseylon will be found at page 118 of the *Geographical Magazine* for 1878.

survey of the port of Akyab, in the vicinity of which several wrecks had occurred, but owing to an outbreak of cholera it was impossible to continue operations, although the necessity for a thorough survey of the place was much felt, as it is much frequented by rice traders and as a harbour of refuge.

Another survey which had to be abandoned through an epidemic of cholera was that of Chittagong (Karnaphuli river), where the encroachment of the sea had necessitated the removal of the lights at Norman's Point to some more suitable place. Lieutenant Hammond had been entrusted with this work, but on the arrival of Commander Taylor most of the party were found to be suffering from fever and dysentery, healthy drinking water being unprocurable, and heaps of half-burnt or half-buried human corpses encountered here and there by the surveyors in course of their work. Operations were therefore broken off.

A large number of questions affecting navigation, such as the hindrances to the free navigation of Bassein river, brought to the notice of the Secretary of State by the Liverpool Shipowners' Association, rules affecting emigrant ships (for the better protection against fire), improvements in signalling on Indian coasts, amendments of Native Passenger Ships Act of 1876 with reference to long and short voyages and seasons of fair and foul weather, &c., were forwarded for report by the Government to the Superintendent of Marine Surveys. The preparation of a complete list of Indian lighthouses and light-ships, with details of cost of erection and maintenance, their positions, distinctive characteristics, &c., was undertaken, as well as the Annual Return of Wrecks and Casualties in Indian Waters. Hydrographic Notices containing sailing direction for Junkseylon or Salang island, Mergui archipelago, Rangoon river, Moulmein (Salwen) river, Kyouk Phyou, and False Point were published, and Notices to Mariners relating to new lights, buoys, and newly-discovered dangers were also published and issued to the Indian maritime authorities, and to foreign Governments, while the English, Spanish, Dutch, American, Chinese, German, and Indian notices were duly embodied and marked (so far as applicable) on all the charts in store. Altogether 3,279 charts were corrected and brought up to date, and a new catalogue of charts was issued.

In the following year (1877) the Superintendent carried into effect his deferred tour of inspection of the ports of the peninsula of

India on both coasts from False Point round to Bombay. The following were visited and reports made on each :—

False Point.	Colachel.
Gopalpur.	Cochin.
Calingapatam.	Narakal.
Bimlipatam.	Beypur.
Vizagapatam.	Calicut.
Coconada.	Tellicherri.
Masulipatam.	Cannanur.
Madras.	Mangalore.
Negapatam.	Karwar.
Tuticorin.	Bombay.

Owing to the special surveying steamer which was being built at Bombay not being completed, the surveying operations during the year were entirely carried on by two boat parties, one in charge of Lieutenant Jarrad, R.N., and the other (a smaller one) in charge of Mr. Morris Chapman, late I.N. The first-named party surveyed the port of Ratnagiri (including Mirya and Kalbadevi bays) in four months, the plotting comprising 38 miles of coast and 21 square miles of water sounded on the scale of 4 inches to 1 nautic mile. Viziadrug, including Rajapur and Ambol Ghur bays, was next taken in hand, and sailing directions for all these parts in the shape of hydrographic notices were also compiled. Both at Mirya and Viziadrug the large percentage of iron contained in the laterite (which in some places forms a layer of considerable thickness over the igneous rock of which the coast is formed) exercised a very considerable disturbing effect on the compass needle, so it was with considerable difficulty that magnetic observations were made. Both on this account and owing to the inconvenience of working with boats in lieu of a well-found surveying vessel slow progress was made.

At Paumben, Commander Taylor had found during his tour of inspection that an accurate survey of the pass or channel between India and Ceylon and its approaches was much required; the only existing chart being on too small a scale. The Government of India further desired that the examination might be complete, so as to enable a time estimate to be formed of the labour required for any subsequent widening and deepening of the channel. The last survey by Commanders Powell and Ethersey, late I.N.,

had, curiously enough, been made exactly 40 years before. Several trigonometrical stations had been fixed in the vicinity by Major Branfill at the time of his connecting India with Ceylon in 1875, consequently Mr. Chapman was enabled to connect his marine work with ease and accuracy. The whole survey was shown on two sheets, and no fewer than 455 miles of water were sounded over. Navigating Lieutenants Hammond and Pascoe paid a visit to Cochin, Beypur, and Calicut to ascertain what changes had occurred since the last surveys. At the first-named nearly half of Vypeen island was discovered to have been washed away, and other changes had taken place necessitating a re-survey. About 10 years ago the monsoon sea breached through Vypin island at Cruz Milagre, two miles north of the town, and so large was the body of water that great and costly efforts were made to close it. These fortunately succeeded, but during the two years of existence of the gap, the main ebb stream of the Cochin backwater was much weakened, and the sandy ridge of the bar was driven in about a cable's length by the monsoon swell, besides other changes. At Beypur and Calicut minor hydrographic data were noted, and the recess was utilised by Lieutenant Pascoe in preparing the fair drawings of the extended survey of Madras, which was added to the previous survey by Lieutenant Jarrad in 1876, the whole being shown on one sheet and plotted on the scale of 10 inches to 1 nautic mile. It extended from St. Thomé on the south to Kasimodo on the north, and comprised $5\frac{3}{4}$ miles of coast, while the soundings were carried out to the 10-fathom line, *i.e.*, between two and three miles off shore.

Some important additions to the hydrography of the Siam coast were received from Captain A. J. Loftus, Topographer and Marine Surveyor to the Siamese Government. The hydrographic work executed by him extended along the west coast of the Gulf of Siam from Hilly Cape to Lem Chang P'ra, a distance of upwards of 300 miles, and embraced Singora, Patani, and other anchorages hitherto entirely unsurveyed, and indeed unknown, and filled up a distinct gap in the existing charts of the coast. The work was well produced; elaborate notes were appended to the sheets explaining how the survey was carried on, as well as a large number of views of various parts of the coast. These sheets were reduced to convenient scale by Mr. R. C. Carrington and published by permission of the Government of India at Calcutta.

The natural history investigations of the season 1877–78 were necessarily confined to examining, collecting, and preserving specimens of the fauna of the shores near Ratnagiri and Viziadrug. The area examined included the tract from the sea to the Western Ghats. It is only on the slopes of the hills that the various fauna begin to be at all abundant, or to assume any individuality of their own. All the intervening tract of country is parched and barren, and composed of a thin soil overlying a substratum of trap rock or laterite, the latter being apparently detrimental to the development of animal organisms. The want of an efficient surveying vessel hampered Dr. Armstrong's operations, but a list of about 60 ornithological specimens collected by him finds place in his report for 1877–78. Among miscellaneous papers submitted to Government by officers of the Department and printed in the Appendix to the Report for the year were the following :—

Remarks on some ports of the Madras Presidency, after inspection in April and May 1877. By Commander Taylor, late I.N.

Report on some harbours, &c. of the Bombay Presidency, after an inspection tour in May 1877. By Commander Taylor, late I.N.

Remarks upon the supposed silting up of the upper portion of Bombay harbour. By Commander Taylor.

On the history of some of the oldest races now settled in Bombay. With reasons for supposing that the present island of Bombay consisted in the 14th century of two or more distinct islands. By R. X. Murphy, Esq.

Extract from report by Mr. Morris Chapman, late I.N., on Paumben channel and Rameswaram island.

In addition to various useful pieces of work performed by Mr. Carrington in the compilation of new charts and of hydrographic publications may be mentioned the result of a visit of inspection to Bombay paid by him, on which occasion he examined the whole collection of charts (11,787 in number) stored in the dockyard there. Of these, the vast majority (10,045) proved to be quite obsolete, and had consequently to be cancelled; the remainder (1,742) were corrected by hand up to the latest date by Mr. Carrington, and retained for issue to masters of vessels.

One of the first matters to be settled in 1878 was the selection of localities where tide-gauges should be erected, with a view to the determination of the mean sea-level along the Indian coasts. This was settled by Commander Taylor in concert with Captain

A. W. Baird, R.E., Superintendent of Tidal and Levelling Operations, visits being paid to False Point, Vizagapatam, Madras, Paumben (where, at Commander Taylor's instance, Mr. Morris Chapman was deputed to extend his survey three miles to the eastward), Beypur, Karwar, and Bombay.

Later on, Commander Taylor was enabled to carry out a further inspection of several harbours in company with Colonel Thomason, and Verawal, Seraia, and Cutch Mandvi were visited. In connexion with the Gulf of Cambay a petition signed by upwards of 70 native shipowners and shipmasters was submitted to the superintendent, stating that in consequence of the existing lights being insufficient, and of the imperfect state of the chart, a large number of vessels were either wrecked or damaged every year by sand-banks in the gulf. The petitioners solicited that a thorough examination of the gulf might speedily be made in the interests of navigation; but owing to the want of a steamer, this could not be taken in hand.

A pressing request was also addressed to the superintendent to cause a survey of Bankote river mouth to be made, as it had the largest traffic of any of the Konkan rivers, and was at the same time very dangerous. The request was supported by Sir Richard Temple, the Governor of Bombay; but as the survey formed no part of the programme of operations sanctioned by the Government of India, it could not then be undertaken. It was, however, thoroughly surveyed by No. 1 Boat party in the following year. An examination of Quilon roadstead was also asked for in the interests of the Scottish India Coffee Company, who had large investments in South Travancore; but this could not be undertaken till 1883, when it was completed by Lieutenant Pascoe.

As in the preceding season, surveying had to be carried on in boat parties, under the command of Lieutenant Jarrad and Mr. Morris Chapman. At the request of Sir R. Temple, Governor of Bombay, the port of Jyghur, a harbour of refuge during the S.W. monsoon, and its approaches were surveyed on the scale of 6 inches to 1 nautic mile. Although small, the harbour was found to possess many natural advantages, and to be easy of access for vessels of 12 feet draught in all weathers. Lieutenant Jarrad reported there was not much traffic, though at Saichor, about four miles from the entrance, a very large number of pattimars were laid up and repaired during the monsoon. The entrance to the

Dabhol or Anjanwil river, where the passenger traffic by coasting steamers was rapidly increasing, was next taken in hand and plotted on a double-elephant sheet on the same scale as the above survey, as well as that of Chaul, where the Chaul Kadu and other dangerous reefs and shoals had caused many a wreck to vessels making for Bombay harbour.

Early in September 1878 Mr. Morris Chapman commenced his survey of Tuticorin roadstead and harbour, the soundings being carried out as far as the 5-fathom and 7-fathom line to the north and south respectively. The heat was most trying, and the weather so exceptionably bad that a suspension of the work became necessary. Mr. Chapman was deputed to make an examination of the water space eastward of the Shingle islands at Paumben, principally with the object of finding a southern deep entrance to the proposed ship canal through Rameswaram. Forty miles of soundings were taken, but there proved to be no deep southern entrance, though there are great advantages for one to the north. On the 16th March Mr. Chapman became ill from severe exposure, and though he was granted two months' leave to enable him to proceed to Australia, he unfortunately died before the season closed. He was a painstaking and hardworking surveyor, and his loss was severely felt in the Department.

On the 4th December 1878 the building of the new surveying steamer "Investigator" was commenced, and the formality of driving the silver nail into her stem took place. The ceremony, peculiar to Bombay, is said to be of Parsee origin, and is somewhat analogous to that of depositing coins, &c. under foundation stones. The nail was of silver, about seven inches in length and three-quarters of an inch diameter near the head. The four sides bore the inscriptions:—(1) Indian Government surveying steamer "Investigator," Bombay Dockyard, December 1878; (2) The Right Hon'ble Lord Lytton, G.C.S.I., Viceroy and Governor-General; (3) The Hon'ble Sir R. Temple, G.C.S.I., Governor of Bombay; (4) Captain G. O'B. Carew, I.N., Officiating Superintendent of Marine, and Jamsetjee Dhunjeebhoy Wadia, master builder.

During the year a Chart Depôt at Calcutta had been established, and was in good working order. Printed lists of all new charts and hydrographic publications, and information as to where the same were obtainable, were distributed to all Indian shipping agencies, and to all shipmasters calling at Calcutta; and the result

was an increase in the sale of Admiralty publications, and of charts of Indian ports and anchorages. Many acknowledgments were received from the maritime public of the practical utility of an office where reliable charts and information were procurable.

Seventeen new charts were issued during the year referred to, and the large number of 17,268 Admiralty and Marine Survey charts corrected. Among the special reports prepared during the year, and reprinted in the Annual Report, were the following :—

Memorandum on the reefs and dangers southward of Kundari Island, and the necessity for better marking those dangers by night, by Navigating Lieutenant Jarrad, R.N.

A description of some new species of Hydroid Zoophytes from the Indian Coasts and Seas, by Surgeon J. Armstrong, Medical Officer and Naturalist.

Reports by Commander A. D. Taylor, late I.N., on the Phaeton Shoal and Alguada Reef, and on the various ports, &c. inspected by him during the season.

A thorough inspection of the lighthouses and light-vessels of India, with such proposals for their improvement as might seem best in the interests of navigation, was one of the early aims of the Marine Survey Department. This inspection Commander Taylor was enabled to carry out in the year 1879–80, and his general report upon the Indian lights is printed in full in the Report for that year. It contains some useful observations and suggestions in regard to 92 lights, from Karachi to Coco islands. A supplementary report in the same volume deals with the question of the relief and supply of Indian lighthouses and their periodical inspection.

Owing to the untimely death of Mr. Morris Chapman, I.N., the temporary abolition of No. 2 Boat party, and the postponement of the surveys of Beypur and Cochin had become necessary; and as Lieutenant Jarrad's health was impaired, arrangements were made for him to remain at Bombay and for an amalgamated party under him and Lieutenant Petley to take up the survey of the Bombay harbour, which the experience of the previous year had shown to be necessary.

The first survey undertaken, however, was that of Karwar, which was plotted on the 6-inch scale by Lieutenant Petley; but owing to the inefficiency of the small steam cutters at the disposal of the party, the survey could not be extended so far to the north and south as was desirable. Bankote was also surveyed on the same

scale, and on its completion the party moved to Marmagao, where a minute examination of that port was made at the request of the Bombay Government, acting on the suggestion of the Engineer-in-Chief of the proposed Hubli-Marmagao Railway. This work was completed at the hottest period of the year, and was rendered exceptionally trying by the prevalence of the Kanara fever, which occasioned much sickness among the party.

The special reports printed in the Appendix to the Annual Report for 1879–80 comprised reports on False Point harbour, and the great modifications and movements of sand going on there, two memoranda on Coconada, and a new deep channel into the Godavari river, and a memorandum on the proposed breakwater at Marmagao, all by Commander Taylor, while some general notes on the topography and history of the latter place were written by Lieutenant Petley, with the assistance of Dr. J. Gerson da Cunha.

During 1880–81 the surveying operations consisted of a careful survey by Lieutenant Petley of the Bombay foreshore from the Prongs lighthouse to Mazagon, and to an average distance of 7,500 feet seaward. The result was to discover many rocky patches and also less water on the Raleigh shoal than shown on the existing charts. Lieutenant Petley then proceeded to Goa, where by the 20th February all the seaboard coast and islands were mapped and 55 square miles of water were minutely examined, the sounding lines being run in sections, those over shoal and dangerous ground being as close as possible. The Portuguese Governor-General took great personal interest in the progress of the survey, and had it not been for this, the difficulties would have been far greater than they were, for the natives somehow formed the idea that the survey party were connected with the new salt tax treaty, which was very unpopular, and many petty annoyances often occurred. The survey of the Sunchi reef was awkward and perilous, as the sea when apparently quite smooth would suddenly pile up on the reef and develop into tremendous breakers, and with the place full of sharks, the danger from a capsize was great. A good descriptive and historical sketch by Lieutenant Petley of Goa, its forts, churches, rivers, islands, &c., is printed in the Appendices to the Reports for 1879–80 and 1880–81. In the month of May Lieutenant Petley made a hasty survey of the approaches to Princes Dock, Bombay. The general result of the season's work at

Bombay was that eight miles of coast line were triangulated and 20 square miles of water soundings were taken.

Lieutenant W. H. Coombs commenced a survey of the port of Rangoon in November 1880 and completed it in March of the following year, the space sounded being eight square miles, and the length of coast measured a little more than 20 miles. Some notes on the history and topography of Rangoon were compiled by Lieutenant Coombs during his stay, and find place in the Report.

During the summer and autumn of 1881 Mr. P. J. Falle executed a survey on the scale of 400 feet to the inch of that portion of Dowdeswell island (Orissa coast) which lies north of Hukitollah, and is most seriously affected by the action of the winds and waves of the southerly monsoon, as also by the river freshets. Mr. Falle also made observations later on in the year on the set and velocity of the tides in the harbour.

On the 3rd March 1881 the new surveying steamer "Investigator" was launched, and Lieutenant L. S. Dawson, R.N., an able surveyor of 18 years' standing, possessing considerable experience of hydrographical matters, was appointed to the command of the vessel. He eventually succeeded Commander Taylor in the Superintendentship of Marine Surveys.

The work at headquarters consisted in tendering advice on a variety of matters of a scientific description affecting navigation to the Government of India and the local governments and administrations. In May 1881 the superintendent was appointed President of a Committee on Indian Lighthouse Administration.

In 1880 events arose which ultimately had a most important bearing on the future of the Department. In the early part of that year disagreements began to crop up between Mr. R. Carrington, the Superintendent of the Drawing Branch, and some of the Royal Navy officers who had been lent for surveying service by the Lords of the Admiralty, and this culminated in the services of Navigating Lieutenant F. W. Jarrad, R.N., being replaced by the Government of India at the disposal of the Admiralty on the 6th February 1880. Lengthy correspondence followed between the Indian Government, the Commander-in-Chief on the East Indian Station, the Lords of the Admiralty, and the Secretary of State for India. This led eventually to the Government of India determining to institute an inquiry into the working of the Marine Survey Department, and a committee was appointed for the purpose under the presidency of

Major-General J. T. Walker, R.E., Surveyor-General of India, the other members being Mr. D. M. Barbour, officiating Accountant-General of Bengal, Mr. H. F. Blanford, F.R.S., Meteorological Reporter to the Government of India, Commander A. D. Taylor, late I.N., Superintendent of Indian Marine Surveys, Commander A. D. Street, R.N., Assistant Secretary to the Government of India in the Military (Marine) Department, and Mr. C. E. Palmer, R.N., Examiner of Marine Accounts as Secretary. The chief proposals of this Committee were that the Survey Department should be amalgamated with the Indian Marine and that a rather smaller surveying establishment than the original one should be sanctioned. The head of the department was to be styled Superintendent of Coast Surveys in lieu of Superintendent of Marine Surveys, the employment of Royal Naval officers was to be continued, and arrangements were to be made for marine zoological observations and trawling to be carried on in the new surveying steamer, under the supervision of a Naturalist. The post of superintendent was recommended to be conferred on Commander T. A. Hull, R.N., an officer who had had great experience in coast surveying in various parts of the world, and in the projection and compilation of charts in the Hydrographic Office of the Admiralty.* The Admiralty, however, objected to the Superintendentship being given to an officer retired from the Royal Navy, and this proposal had to be abandoned. The general re-organization of the Department too, on the lines laid down by the Committee, did not commend itself to the Admiralty and the Secretary of State, and at the suggestion of the former, advantage was taken of Commander Taylor's prospective retirement to depute Captain H. W. Brent, R.N., the recently nominated Director of Indian Marine, to take up the question on his arrival in India, so as to advise the Government as to the best way of dealing with the Marine Survey Department.

An elaborate report on the Marine Survey Department was compiled by Captain Brent, and its entire work since its origin in 1874 was severely criticised. A series of statements and charges was brought against the Department, but it is enough to state here

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* Captain Hull was author of a remarkable paper read in 1874 before the Royal United Service Institution called "The Unsurveyed World, 1874," which enumerated and specified all the more pressing coast surveys then needed throughout the world. The paper attracted much attention.

that the general purport of this part of the report was to allege that the Calcutta Office or shore establishment had been unduly magnified at the cost of the survey proper, that India required her coasts surveyed, but no Hydrographic Office, and that the most useful and profitable course in the interests of the State was "to break up the Indian Marine Survey Department."

Captain Brent's detailed recommendations regarding the *personnel* and records were as follows:—

Commander A. D. Taylor, late I.N., Superintendent of Marine Surveys, was to be pensioned. The post of Superintendent of the Drawing Branch was to be abolished, and 10 clerks and draughtsmen were to be either transferred to other Government posts or dismissed. All the Admiralty charts purchased by and presented to India, were to be sent back to the Hydrographer, while Indian survey charts were to be sent to Bombay dockyard, together with chart boxes, instruments, drawing materials, tin cases, &c. Surveyors' original charts were to be sent to the Admiralty Hydrographer.

The Wreck Register and the clerk employed thereon were to be transferred after the 1st July to the Port Office, Calcutta, instructions being sent to the Indian ports to send all information in future to that official instead of to the Marine Survey Department. The Port Officer has since carried on this duty in addition to his own work. The Annual Return of Lighthouses and Light-vessels was to be handed over to the Home Department, and the *Notices to Mariners* abolished, on the ground that they could always be procured from London. Captain A. W. Stiffe, the Port Officer, was directed in 1887 to prepare a new corrected edition of the former Return, and to the same officer was also entrusted the duty of issuing all Notices to Mariners relating to India.

With respect to the future conduct of surveys, Captain Brent laid down at the outset that it was only from the active list of the Royal Navy that efficient marine surveyors could be obtained, and that the Indian surveyors should be therefore nominated by the Admiralty, the posts of assistants being filled by officers of the Indian Marine. But the two classes were to be kept distinct, there being no promotion from the lower to the higher grade. Their work was to be sent home directly to the Hydrographer, such charts as might be

required promptly for local navigation and engineering wants being first photo-zincographed in India. Printed Admiralty charts of the coast of India were in future to be corrected at the Admiralty. In the opinion of Captain Brent the "Investigator" steamer and two boat parties would be sufficient at least to start the surveys with. Unfortunately, however, it has never been found practicable to increase this force.

The future establishment was to consist of a surveyor in charge (in lieu of the Superintendent), who was to be placed in command of the "Investigator," direct the boat surveys, arrange all survey work and connect it with the points of the Great Trigonometrical Survey. The programme of operations was to be submitted through the Director of the Indian Marine to the Government of India for sanction. The surveyor in charge was to decide which of the surveys would be of sufficient importance or use to be photo-zincographed, and he was to countersign the original charts before forwarding them to the Hydrographer of the Admiralty, to decide on the form of all hydrographic information, whether emanating from the marine surveying officers, port officers, or other sources, and to forward such information to the Admiralty for publication. He was to communicate with the Hydrographer of the Admiralty respecting past operations and those most pressing in the future from a local or Indian point of view, obtaining his approval or dissent before acting on the more important points. To report to the Hydrographer as to any changes in the naval personnel and to the Director of Marine any changes in the Indian personnel likely to prove of benefit to the public service. To make demand on the Hydrographic Office in England for such charts, surveying notices, or publications as may be necessary to meet local Indian requirements. To answer any questions relating to harbour conservancy by means of buoys, beacons, or lights; those of a secondary nature to be kept for the recess.

Owing to the arduous character of the duties and the trying nature of the climate, it was stipulated that the duration of the appointments should be limited to five years, renewable if advisable. The naval officers were to come under the Uncovenanted Civil Service rules for leave and furlough, but, to count their time and to keep them under the Naval Discipline Act, their names were to be borne on the books of the flagship on the East India station or such other ship as might be necessary from time to time.

There was to be an office at Bombay under the Director of Marine with two draughtsmen and a clerk, and these officials were charged with the custody and care of the charts.

Local governments and administrations and the several port officers were to promptly communicate all information regarding wrecks, lights, navigation, buoys, beacons, shoals, or other matters affecting the safe navigation of the seas, to the Director of Marine for the information of the surveyor in charge. The surveyor in charge was to be the adviser to the Government of India upon all matters connected with the navigation of Indian seas, the lighting and marking of the sea approaches to all great Indian ports and rivers, conservancy of harbours, and cognate subjects.

This general scheme was approved by the Government of India.* The proposed staff as agreed to by them was to consist of one surveyor in charge and seven officers, all of the Royal Navy, and nine assistant surveyors of the Indian Marine. The total cost of the scheme was to be Rs. 1,93,000, which was estimated to be a saving of Rs. 7,000 a year on the cost of the then existing establishment (Rs. 2,00,000 per annum), but as the *actual* expenditure of the latter was about half a lakh less than its sanctioned limit, the new scheme was in reality the more costly of the two.

The Secretary of State duly accorded his sanction to these proposals, and the retirement of Commander Taylor on the 1st July 1882, under the 55-year rule, enabled the re-organization to be completed. He was succeeded in the charge of the Marine Surveys by Commander L. S. Dawson, R.N.

Commander Alfred Dundas Taylor, whose active Indian career thus practically came to an end, is an officer whose public service here merits some notice.

His earliest eastern services were rendered in the Persian Gulf when he was a midshipman on board the Honourable East India Company's ship "Elphinstone." On leaving that vessel in June 1843 he was granted a certificate as "a first-rate navigator who promised to be as "good an officer." His surveying career commenced in the following year under Commander Montriou (succeeded later on by Lieutenant Selby) in the brig "Taptee," along the Concan coast below Bombay, and this work was carried on for four years. Promoted to the rank of lieutenant in 1847 the next two years found him on board the

* Military (Marine) Letter, No. 29 of 1882, dated 1st September 1882.

steam frigate "Feroze," in the Red Sea. In the autumn of 1850 he was appointed to command the surveying vessel "Pownah," in which, during the next six years, he carried out a survey of the Gulf of Cutch and the Malabar coast. In 1855 he examined the port of Karwar, and was then sent by Lord Harris (father of the present Governor of Bombay) to survey Coringa bay and Coconada port, on the Coromandel coast, and Cochin, on the Malabar coast. Resuming the latter survey, he finished southward as far as Calicut by the middle of 1859. Later in that year he was sent to pilot the expeditionary force against the rebellious Waghers at Bet and Dwarka, and then proceeded to England on furlough. In 1862 Commander Taylor was pensioned off on the abolition of the Indian Navy but, at the request of Admiral Washington, the Hydrographer, his services were utilised in the compilation of Sailing Directions for the West Coast of Hindostan, which work was published in 1865. It was during the course of the next few years that in his researches at the India Office, Commander Taylor became aware how little had been done to improve the hydrography of Indian waters, a subject eventually brought by the Secretary of State under the notice of the Government of India, which led to the formation of the Marine Survey Department under Taylor's charge.*

During the six years of its existence, the cost of the Marine Survey Department had been as follows:—

	Rupees.	as.	p.
1875–76 - -	1,66,771	12	5
1876–77 - -	1,40,484	0	1
1877–78 - -	1,38,290	7	2
1878–79 - -	1,60,207	11	7
1879–80 - -	1,13,706	9	11
1880–81 - -	1,94,607	0	0†
Total Rupees -	9,14,067	9	2

Or, on an average, Rupees 1,52,344 per annum.

Under Commander Taylor's superintendentship, *i.e.*, from April 1875 (the date on which work was commenced at headquarters) up to the end of September 1881, the publications of the Marine Survey Department consisted of the following:—68 new charts,

* *See* Mr. Markham's Memoir on the Indian Surveys (Second edition), p. 45. Commander Taylor last year (1890) signalized the 50th year of his public service by the compilation of a China Sea Directory, a sequel to the Indian Ocean Directory.

† Including Rs. 83,536, part construction of the surveying steamer "*Investigator*."

24 Hydrographic Notices, 172 Notices to Mariners, 5 Annual Returns of Wrecks and Casualties in Indian Waters (1876–1880), 6 editions of the List of Lighthouses and Light-vessels in British India (1876–1881), and various other useful publications, including Spheroidal Tables, Glossary of French Nautical Terms, Tables of Natural Scales, Table of Distances at which Objects are seen at Sea, &c. The advantages, too, of a chart depôt at Calcutta, where hydrographical publications could be promptly obtained without the long delay of reference to England, were beginning to be fully appreciated by the mercantile public, and in 1880–81 1785 charts were sold, being at the rate of between five and six charts a day.

Such were the results accomplished by the Department during its brief existence. Under the superintendence of its able and devoted chief, and with the co-operation of its energetic officers, it had made a position for itself, and its good work was beginning to be known and thoroughly appreciated by the mercantile marine frequenting Indian seas. Had it been able to survive those internal and external petty jealousies, from which no public department, any more than any other human institution, is exempt, it would undoubtedly have achieved a long record of good work, worthy of comparison with that, which during the present century, has made the history of Indian land surveys so famous and brilliant. Undoubtedly much of the marine survey work has since been continued by earnest and capable hands. But the break-up of a department is seldom unaccompanied by evils; the old personnel vanishes, the old lines are obliterated, the experience which it has taken years to build up, is either discredited or wholly lost, and the result is, even at the best, a serious interruption to that record of continued progress and development which are the aim of all English administrations.

II.

INDIAN MARINE SURVEYS.

Second Period, 1882–90.

The Indian coast surveys now entered on a new chapter of their history. The headquarters had been moved from Calcutta to Bombay, future operations were to be mainly confined to surveying, *pur et simple,* and Commander L. S. Dawson was appointed to their charge on the 1st July 1882,* in the place of Commander A. D. Taylor, late I.N., retired.

The "Investigator" paddle steamer, 508 tons, was now available for surveying purposes, and was arranged as a sort of floating headquarters of the Marine Survey Department, a complete set of charts, sailing directions, pilotage books, and works of reference being taken in her, to enable Commander Dawson to deal with any hydrographical question or reports referred to him.

During the year 1881–82 her officers performed the following survey work:—

Place.	Scale.	Area Sounded in Square Miles.	Coast Line in Square Miles.	Topography triangulated and drawn in detail.
Malwan - -	6 inches to 1 mile	21	17·5	13
Vingorla -	6 " "	11	7	10·5
Bombay - -	5 " "	32	11	4
Do. - -	2 " "	81	20	30
	Total -	145	55·5	57·5

* Commander Dawson had been employed (while Lieutenant) as Naval Assistant in the Hydrographic Department of the Admiralty since 1876. He had previously had 10 years' experience in surveying in the Mediterranean, China, River Plate, New Guinea, and at Fiji, where he commanded the schooner "Alacrity."

The boat party, in charge of Lieutenant W. H. Coombs, R.N., also did some useful work. It executed a survey of False Point, on two sheets, the scales being 600 feet to 1 inch, and 4 inches to 1 nautic mile, respectively. For the first month the whole of the work had to be carried on with only the whale boat, and all the officers and men suffered more or less from the malarial fever, for which the place is notorious. The remainder of the season was taken up with surveys of Santapilly reef, Coconada, and the southern portion of Madras harbour.

During most of the following year the charge of the surveys was temporarily transferred to Lieutenant A. Channer, R.N., and under his superintendence a survey of the Karil Kachal channel and Vingorla rocks was made, after which the "Investigator" weighed anchor and proceeded to run a line of deep-sea soundings parallel to and about 60 miles off the coast to the Gulf of Manar, and across the gulf to Colombo, passing over the "Wedge bank."

The next work undertaken was a survey, in December 1882, of the Dhumra river entrance, and the portion of the Baitarani (Byturnee) river from its junction with the Dhumra up to Chandbally, and the following month Balasore roadstead and Burraballung river up to Balasore town were charted. The "Investigator" next proceeded to Chittagong, where a rough reconnaissance of the Meghna river, from Narayanganj to Sandwip channel, and of the Karnaphuli or Chittagong river, to three miles seaward was made, after which the ship returned to Bombay.

No. 1 Boat survey party, which had been in abeyance during the previous year on account of the officers formerly composing it having been required for duty on board the new surveying steamer, was reconstituted on the 1st October 1882. Under Commander Dawson, a survey of Back bay, Bombay, on the scale of two inches to the mile, was commenced, and continued and completed by Lieutenant Pascoe, the result being to show a slight deepening of the bay to the northward as compared with Lieutenant Whish's survey of 1861. Karachi harbour was next taken in hand, and plotted on a double-elephant sheet, the work comprising 19½ miles of coast line, and 16 square miles of sounding. A decided silting of the harbour on the west side, and also a great decrease of water space to the northward by the Puhi and Soti creeks were revealed, and westward of Manora Point several rocky patches, where numerous vessels had lost their anchors, were found, and clearly marked and

defined. The party were then conveyed to Beyt harbour, in Baroda State, where the fixing of the position of the new lighthouse, in process of building, and a plan of the harbour and entrance channels were desired. This survey was duly completed on the 4-inch scale.

No. 2 Boat party, under Lieutenant W. H. Coombs, undertook surveys of the entrance to the Chittagong river, and of Akyab, the latter being on the scale of 3 inches to the mile and embracing an area of 60 square miles. Operations were much delayed by the deplorable condition of the steam cutter, which broke down continually, and which Lieutenant Coombs was obliged to work at a dangerous amount of pressure to enable him to get even so moderate a speed of three knots an hour.

The total work during the season showed an exceedingly good record, the "Investigator" and the two boat parties having been all working at their full strength. Exclusive of the Meghna reconnaissance, 320 square miles of soundings had been taken, and 32 square miles of topography in detail, 250 coast line in linear miles, and 60 deep-sea soundings made. The "Investigator" was reported by Lieutenant Channer to be admirably adapted for the work, being very handy and light in running soundings from 25 to 100 fathoms.

At the beginning of the season, 1883-84, Commander Dawson resumed charge, and the first piece of work undertaken was the survey of Cochin on the 8-inch scale, which some four years previously had been postponed owing to the death of Lieutenant Morris Chapman, late I.N. The Cochin river entrance, the bar, and backwater were all sounded, the area amounting to 12¼ square miles, and the positions of the bar buoys, as previously laid down, were found to be considerably in error. The vessel then proceeded, viâ Colombo, to the coast of Burma, and on its way took a line of deep-sea soundings across the Bay of Bengal from Dondra head, the southernmost point of Ceylon, to the vicinity of Cheduba island. At the mouth of the Sandoway river Lieutenant Channer was left for the purpose of surveying the approaches to Tongoup and Sandoway, while Commander Dawson went on to the entrance of the Rangoon river, where numerous complaints had been received as to the extension of the banks, silting of channels, and general alterations in the hydrography of the Rangoon river. This survey proved to be lengthy and difficult, and several new channels and

great changes in the main condition of the river were ascertained to have taken place. It was completed in the early part of March; no fewer than 168 square miles being sounded over on the 2-inch scale in the Rangoon river and its approaches, from the China Bakir river and entrance to the Port of Rangoon. The port itself was sounded on the 6-inch scale. It was ascertained that the time of high water at full and change of the moon at Rangoon had become about 45 minutes earlier than it was in the year 1829, a change accounted for by the scour of the river having increased in consequence of artificial embankments, &c.

Cheduba strait and Ramri roadstead were next taken in hand, a detached boat party under Lieutenant Helby, R.N., being told off to the former, while the "Investigator's" officers were engaged on the triangulation of the whole, as well as on the detailed survey of Ramri strait. The survey of the approaches to Sandoway and Tongoup, covering 301 square miles, had been made as mentioned above by Lieutenant Channer.

Boat party No. 1, under the charge of Lieutenant T. C. Pascoe, was employed during the latter part of 1883 on the survey of Quilon, where the Travancore Government was anxious to construct a deep-water harbour, there being no other harbour on the Travancore seaboard, and the backwaters, which extend 100 miles altogether to the north and south, offering great advantages for boat traffic up to the foot of the hills. The party returned to Bombay by Christmas day, and the remainder of the season was taken up with the surveys of Mahuwa or Mowa and Shial Bet.

No. 2 Boat party, under Commander Falle, I.M., mapped out Vizagapatam and Calingapatam, and under Lieutenant Morris Smyth, R.N., who took charge on the 1st February, made a survey of Negapatam and Nagore.

Thus the full programme drawn up for the Season 1883–84 (with the exception of the search for the Sacramento shoal, which owing to the want of a vessel for the purpose had to be abandoned) was carried out, with the additions of the entrance to the China Bakir river, the approaches to Sandoway and Tongoup, and the port of Negapatam. The total out-turn for the season amounted to 11 charts and plans, covering 746 square miles of soundings, with 15 deep-sea soundings.

The next year (1884–85) saw Commander Alfred Carpenter, R.N., assume the direction of the operations, in place of Commander Dawson, the Department during the interval between the two commands being placed in charge of Lieutenant Channer, R.N. The "Investigator's" first course was to Sandoway Roads, where work was immediately commenced in continuation of the Cheduba and Ramree harbour surveys of the previous season.

The Cheduba straits were completed in December 1884 after a year's work, during which 83 linear miles of coast and 905 square miles of soundings were charted, new shoals were discovered, and the so-called Port Childers, formerly described as an excellent harbour, was proved to be full of dangerous pinnacle rocks.

An examination was made of the Orissa coast from Dhumra river to Balasôr, but no detailed marine survey of the shore was carried out. Soft mud flats dry at low water extended two or three miles off its entire face, while dense jungle and mangrove swamps formed the actual coast. Many of the stations along the shores made by the great trigonometrical surveyors some years previously had become submerged: the two-fathom line extended from three to four miles off shore, and at six miles no portion of the coast could be seen from a ship's deck.

A camping party, landed on Shortt island, proceeded to delineate the Palmyras shoals, 88 square miles of which were charted, while the "Investigator" re-sounded the whole of the bank of soundings (or Pilot's Ridge) between False Point, Palmyras Point, and the Eastern channel light-vessel, carrying the soundings out to 30 fathoms. The positions of the various soundings were found astronomically, and every observation carefully checked by four or five observers, each with his own sextant, as attention had been repeatedly called by captains of vessels bound for the Hugli river to the erroneous nature of the soundings on published charts of this part of the Bay of Bengal.

The result of the survey showed an almost identical bottom contour to that on the Admiralty chart (False Point to Mutlah) as delineated by Mr. R. C. Carrington. The amount of square miles sounded over by the Pilot's Ridge survey was 2,400. On its completion the "Investigator's" boats assisted in sounding the extreme seaward face of the Palmyras shoals, which had apparently projected eastward half a mile from their former position.

The bar of the Dhumra river was found also to have altered considerably since 1882.

In March 1885 an examination was made by the "Investigator" of the curious submarine ravine called the Swatch-of-no-ground, south of the Sundarbans. It was found to have an average breadth of nine miles, with a floor of from 600 to 400 fathoms depth, and inclined sides of soft mud of about 1 in 4. The mouths and sands of the whole delta of the Sundarbans converge to throw their ebbing waters towards the Swatch, and one suggestion has been that the eddy caused by these waters meeting has tended for many ages to prevent the mud held in suspension from settling over the central cleft, and thus the banks on either side have grown seaward while the Swatch has retained its original depth.

The result of the 1884–5 season's work of the Marine Survey of India was 11 charts and plans, including one of the entrance to the Rajpuri river by a boat's party, under Lieutenant E. Helby, R.N. The "Investigator" ran also over 4,500 linear miles of soundings. In the department of zoological and botanical work the general experience of Commander Carpenter, R.N., and Lieutenant Channer, R.N., who had both served on board H.M.S. "Challenger," proved most valuable. Under the supervision of Mr. G. M. Giles, M.B., F.R.C.S., who acted as surgeon-naturalist, some interesting hauls from deep-sea trawling were made, though the appliances had been long disused, and the microscope was one of very old-fashioned construction.

On the whole the season of 1884–85 had been one of fair weather, and the outcome of work was larger than during any previous year.

In March 1885, the "Investigator" left the Sunderbuns and carried a line of soundings to Kyauk-pyu in Arakan, where a survey of that port was commenced and finished in April. Seven deep-sea soundings were taken diagonally across the Bay of Bengal, on the same line but between the soundings taken by Commander Dawson in December 1883, and thus a complete section of the bay was obtained, the average distance between the casts being 70 miles. The surface temperature averaged 86°·5; that of the abysmal regions of the open ocean is universally low, the mean temperature of the sea bottom being everywhere about 36° in very deep water, this being the temperature of greatest density.

The following charts and plans were draughted :—

—	Scale.
CHARTS.	
Approaches to Sandoway	1 inch to a mile.
North and West coasts of Cheduba	½ " "
False Point to Mutlah river	¼ " "
Sketch of Orissa coast	1 " "
PLANS.	
Ramree harbour, Cheduba	3 inches to a mile.
Cheduba strait	2 " "
Kyauk-pyu	3 " "
Palmyras shoals	3 " "
Mergui harbour	6 " "
Tavoy river	2 " "
Bhaunagar, Kathiawar	6 " "
" " (in three sheets)	20 " "
Rajpuri or Janjira harbour	4 " "

All the above, with the exception of the large scale of Bhaunagar (which was for local engineering purposes), were completed and sent to the Hydrographer, and four of the plans were photo-zincographed at Poona and sent to the Chief Commissioner of Burma for local distribution.

The approaching outbreak of war with King Theebaw necessitated some scheme for piloting a flotilla advancing on Mandalay and Bhamo, for buoying the river and for preserving the buoys, as native pilots beyond the frontier were not to be had. A river survey party under Commander A. Carpenter, R.N., was accordingly formed, with a small reserve party under Commander P. J. Falle, I.M., which was established at Pagan, about half-way between the frontier and Mandalay. The main party, on joining the war flotilla at Minhla, were sent forward to lead the fleet up to Mandalay, throwing

the survey launch ahead to sound whenever there was a doubt as to which channel the main stream had adopted for the dry season. The possession of a gun and a bluejacket's crew were a very serviceable help to them when sounding ahead of the other vessels. Commander Carpenter and his party then piloted the flotilla up to Bhamo, having first taken the pilots over the shallowest portions and examined the latest-formed channels. A complete sketch survey was made of the river from Thayetmyo to Bhamo, and was checked by astronomical observations at 20 positions, forming altogether a valuable addition to geography. The survey party returned to Rangoon and rejoined the "Investigator" towards the end of January, having received the thanks of General Sir H. Prendergast for the skilful assistance which they had rendered to the Irawadi war flotilla.

The next survey taken up was that of the Mergui archipelago, the Admiralty chart of which (by Captains Ross and Lloyd of the Indian Navy) was found to be very correct, the only defect being an insufficient number of soundings. The islets are all steep, and many are mere pinnacles, which makes it probable that similar dangerous pointed rocks exist below water. The Great Western Torres islands, immense heaps of boulders overgrown with foliage, were visited, and their position tested by angles to known peaks and found to be 1½ miles out.

About this time a fresh datum for the low-water level on Indian charts was resolved upon. Previously, the soundings used to indicate the depth at the average lowest tides of all the lunar fortnights during the year, but as this had been proved by the observations of Major Baird to give in some cases more water than actually existed, owing to the considerable difference on the west coast of India between night and day tides, and on the East and Burmese coasts between winter and summer ocean level, it was decided that all soundings and tide tables should be reduced to the lowest low water of the year, provided it was not phenomenal, *e.g.*, brought about by an earthquake or cyclone. The only exceptions to this rule was to be made at Karachi, Marmagao, and in the River Hugli, where the harbour authorities sound their own ports and prefer their own reduction datum. This, however, was a matter which would not confuse the mariner, as at such ports pilots are obligatory.

Lieutenant E. C. H. Helby, R.N., in charge of No. 1 Boat survey party, completed the survey of the approaches to Bhaunagar commenced in the previous season. The soundings extended over 104 square miles, charted on the scale of three inches to a nautical mile. No. 2 Boat party, under Lieutenant M. H. Smyth, R.N., was engaged in buoying the China Bakir entrance to the Irawadi river, and in the survey of Mergui, already mentioned.

On the "Investigator's" return from the Western Torres islands, in March, she completed the southern approach to Mergui, taking in some 20 miles of the beaten track to the southward. Preparis, Narcondam, and Barren islands were next visited. From the last two islands radiating lines of soundings were carried out to ascertain their slope to the floor of the ocean. It was found that they rose from a depth of 1,140 fathoms, but that the north-east slope of Narcondam was being encroached upon by the outlying banks from the great rivers flowing into the Gulf of Martaban. The temperature observations taken seemed to favour the inference that no greater depth than 760 fathoms exists in any of the passages between the Andaman islands or between that group and Acheen.

In May, Lieutenant A. Channer, R.N., was again appointed as Surveyor in charge (Commander Carpenter being absent on leave in England). The following charts and plans were drawn during the recess:—

Irawadi river from Thayetmyo to Bhamo, on $\frac{3}{4}$-inch scale in 4 sheets.

China Bakir river - - - -	on 2-inch scale.
Mergui Fells passage - - -	,, 2 ,, ,,
,, Northern approach - -	,, 1 ,, ,,
,, Kings island to Christmas island -	,, 1 ,, ,,
Cambay Perim to Bhaunagar - -	,, 3 ,, ,,
,, Narbada ,, - -	,, 2 ,, ,,
,, Mandwa Bay, Diu - - -	,, 6 ,, ,,

besides sailing directions, tidal, and other data. These were all completed and forwarded to the Admiralty Hydrographer, copies having been photo-zincographed by the Poona Office.

The first place examined by the "Investigator" was Hinze basin on the Burmese coast; the Moscos islands were then re-plotted, and the beaten track in the Mergui archipelago from Christmas

island, where the survey of the previous season had ended, down to Forrest strait near Pakchan. The track is useful to local trade and gives protection to vessels trading to Singapore, but until thoroughly surveyed on a large scale, which the trade does not at present seem to require, it is not recommended for large and deep draught vessels. In fact, large ships able to steam against the ordinary monsoon would not use it.

On Christmas day a visit was paid to the Elephant islands, close to the south-east side of Domel island. The former are composed of a marble of medium quality, and are very remarkable, both for their abrupt shapes and the beautiful grottoes they contain. The grottoes are mostly accessible at low water through tunnels below high-water mark opening into lofty caves. At the south end of the largest islet, which is 1,000 feet, a low-water tunnel admits a boat into a lagoon, entirely closed by high precipitous cliffs and open only to the sky. Into this lagoon, which seems to be purposely created for smugglers, several cave grottoes open from under the cliffs. An interesting description of these islands will be found in the Records of the Geological Survey.

With the object of examining the banks extending off the Sundarbans between Chittagong and the "Swatch," a survey was made of the Meghna flats. No less than 1,750 square miles were sounded, the result being to show more water in nearly every direction than on the published charts, and no extension of the prominent shoals. No. 1 Boat party completed their survey of the channel between the Narbada river and Perim island in the Gulf of Cambay (Narbada river to Perim island), the triangulation being carried across the gulf from the Kathiawar side to Broach point by means of mirrors which were extemporised as heliostats. Mandwa bay, Diu head, was also surveyed, the area sounded being 10 square miles, while in the case of the Gulf of Cambay it was 65 square miles. Between October and February the "Investigator" was at work in surveying the entrance to the Beypur river, and here, and at Calicut, and off Cotta point, an aggregate area of 139 square miles were sounded and plotted on various scales. Boat party No. 2, surveyed the approaches to the Yé river on the Tenasserim coast on the scale of four inches to the mile, but the work was much impeded and interrupted by the ill-health of the party, until on the 18th November no fewer than 23 were on the

sick list, and work was suspended. Places situated on tidal estuaries where fresh and salt water come into contact are notoriously malarious, and though not of a severe type the disease in this case was extremely persistent.

The natural history results were meagre during the year 1886–87, Surgeon G. M. Giles having been deputed to serve with the Chitral and Kafiristan Mission during the greater part of the year.

Towards the close of March 1887 the "Investigator" completed the survey of the shallows off the mouths of the Meghna river. The soundings on the "South Patches" proved to be even shallower than hitherto supposed. This shoal has caused a great many wrecks from endeavours to avoid it, for sailing vessels arriving off Chittagong with their chronometers often in error after long ocean passages, give it too wide a berth and get wrecked on the Meghna shoals. With the present corrected chart, vessels making for Chittagong should be able to avoid these Patches, while the rectification of the peaks and outlying islets of the Andaman and Nicobar groups will tend to decrease the wrecks on the flats of the Sundarbans by enabling vessels standing up the Bay of Bengal to fix their true positions.

From the "South Patches" a line of soundings was first run south to the latitude of Akyab, and then a line of deep-sea soundings was carried at intervals of 70 miles to Madras, the depths gradually increasing towards the latter place, 1,820 fathoms being obtained 40 miles off Pulicat, near Madras. This line was the first record of the depth of the northern portion of the Bay of Bengal.

Commander Carpenter's paper on the mean temperature of the Bay of Bengal, with its chart, has been published in the Journal of the Asiatic Society of Bengal for 1887, Vol. LVI., Part II. The temperature records afford an extremely useful check on the observations of depth in cases where the sounding wire indicator gets out of order.

Off Madras a closely-sounded survey was made, on the scale of two inches to the mile, of the Tripalur reef and Rockingham patch, where three steamers had grounded, one being lost and another very badly damaged. This survey was connected with the land survey stations. A few soundings were also taken north of Pedro Point in Ceylon, where a gap existed in the soundings showing the eastern entrance to Palk straits.

During the recess the following charts and plans were turned out by the officers of the "Investigator" and her two boat parties:—

Charts.

White Point to Mergui	$\frac{1}{4}$ inch	to 1 mile.
Megna flats	,,	,,
Beypur to Sacrifice rock	$1\frac{1}{2}$ inches	,,

Plans.

Mergui archipelago	$\frac{1}{2}$ inch	,,
Forests strait	1 ,,	,,
Tripalur reef, &c.	2 inches	,,
Beypur and Calicut roads	3 ,,	,,
Yé river	8 ,,	,,
Approaches to ditto	2 ,,	,,
Beypur river bar	12 ,,	,,
Cotta point and reef	3 ,,	,,

All except four of the above have been photo-zincographed for local use, and all except that of the Meghna flats, which was purely astronomical, were based on data of the Great Trigonometrical Survey. Sailing directions, tidal and other data were also compiled.

For the next season the sanctioned programme comprised a survey of the western coast of the Andaman islands, and of the Ganjam coast between Santapilly and Hurrichpoor in latitude 20° N., but later on the Madras Government requested that that of the Ganjam coast might be postponed another year.

A line of deep-sea soundings was carried from Porbandar to the Laccadive islands, one result of which was to indicate that the Laccadive submarine peaks spring from an ocean floor about 1,100 fathoms, or one and a quarter land miles deep, and are themselves about the same height as the Western Ghats in those latitudes.

A curious discovery was made at Chitlac island, tending to prove the existence of a southerly current on the west coast of India. A large wooden tank had floated ashore over the reef in September 1885 with a human skull inside, and from enquiry this appeared to be part of the wreckage of the British Indian wooden barque "Jabree," of 695 tons, with a crew of 60 men and 40 passengers, an account of the loss of which is given in the Wreck Register for 1885.

She had reached Ras-el-Hadd on the east coast of Arabia, when she was caught in a gale and foundered in a few hours; seven of the crew managed to climb into an empty wooden water-tank which had been washed off the deck, and there the seven men lived for ten days without either food or water. After the lapse of those ten days the survivors died one by one, the bodies being flung overboard, and the tank drifting on steadily towards the coast of Cutch at the rate of 28 miles a day. The sixth man died whilst within sight of land, and the last solitary survivor managed to crawl ashore at Jakao, in Cutch. He found a pot of millet, but his throat was so parched that he was unable to swallow it till it was moistened with sea water; thus refreshed he was able to make his way along the shore till he reached a native hut, where he was kindly treated, though laid up for a long time with fever.

Commander Carpenter considers that there is very little doubt that this same tank, after touching the coast at Jakao on the north side of the entrance to the Gulf of Cutch, was driven seaward by the outset of the gulf consequent on the heavy monsoon rains, and drifting southwards along the west coast of India in the southerly current that relieves the pressure of water on the Sind coast during the S.W. monsoon, was carried out to the Laccadives after the monsoon was over.

The "Investigator" proceeded in November to the Andaman islands, which, with the exception of the little Andamans, had been all recently triangulated by Captain Hobday of the Trigonometrical Survey. A coast survey based on the land triangulation, and on the scale of one inch to the mile, was set in hand, and 724 square miles in all sounded. Of the harbour of Port Blair a rough chart by Lieutenant Dickson and Mr. Marshall, I.N., had been made in 1861, and as a more perfect survey was now considered necessary, a detached party under Lieutenant B. Whitehouse, R.N., took this in hand, and completed 16 square miles of soundings on the 5-inch scale, including 288 square miles about the Western Coral banks, which were gone over most minutely to ascertain whether there was any really dangerous shoal water on them. The least water found was six fathoms. On two occasions instead of anchoring on the banks for the night the ship was allowed to drift, and some very rare marine specimens were obtained by trawling, and sent to the Calcutta Museum.

The Andamanese were found to be no longer treacherous nor hostile to Europeans landing on their islands. A great number of them now talk Hindostani, which they learn with great quickness. A tide-watching party placed in tents at the west end of Andaman strait was met by some 30 natives, who left their hut a mile and a half distant and encamped close to the Englishmen. It was at first supposed that they had come for protection against other tribes, but it transpired that they had really come to protect our people, a welcome change of feeling which is attributable to the excellent administration of Colonel Cadell and his predecessors.

During 1887, Lieutenant Helby, R.N., who had been in charge of No. 1 Boat party, brought the survey of Beypur and Calicut to a close in time to recess at Poona in May. Thirty miles of the Malabar coast were well surveyed and the Calicut reefs clearly depicted. Lieutenant Helby then handed charge of the boat party to Lieutenant M. H. Smyth, R.N., who, during 1887–88, made large scale surveys of the small ports of Porbandar and Navibandar in Kathiawar, and also surveyed Cannanur on the Malabar coast, all in excellent style.

In 1887 Staff Commander T. C. Pascoe, R.N., left the Indian Marine Survey and reverted to Admiralty employment after having been 11 years in the Department, during which he had done much valuable work.

A detailed report on the results of the deep-sea dredging casts, by Surgeon-Naturalist G. M. Giles, is annexed to the Marine Survey Report for 1887–8, as well as a tabular analytical catalogue of the collection by Mr. J. Wood-Mason, Superintendent of the Indian Museum at Calcutta. Another appendix is the interesting little paper referred to above by Commander Carpenter, R.N., on the mean temperature of the deep water of the Bay of Bengal, with its accompanying chart, the general effect of which is to show how rapid the fall in temperature is at the varying depths from the surface down to 150 fathoms, while after 1,200 fathoms the change in temperature becomes very slow.

In 1889 Surgeon A. Alcock (who had succeeded to the post of naturalist), I.M.S., was permitted to reside at Calcutta during the recess, for the purpose of arranging the collections made and deposited in the Indian Museum at Calcutta. Thanks to this permission, Surgeon Alcock has been able to make a very large addition

to our knowledge of Indian Marine Zoology, more especially in regard to fishes, of which he has described 44 entirely new to science, and 62 new to the Indian fauna.

In the spring of 1888 the "Investigator," having completed the examination of the outlying dangers on the west coast of the Andaman group, took a north and south line of deep soundings about 100 miles west of the Andamans and Nicobars from latitude 12° 40′ to latitude 5° 45′ N. In the latter position a submarine elevation was found representing a submerged peak rising 2,000 feet high from the floor of the ocean, about half way between the Straits of Malacca and Ceylon.

During the recess the following fair charts (with the exception of the 20-inch Porbandar harbour plan) were drafted and forwarded to the Admiralty Hydrographer:—

Name of Chart or Plan.	Scale.
*Port Blair to Sisters islands	1 inch to 1 mile.
North Sentinel island	" " "
*Port Blair	5 inches "
Macpherson's strait	2 " "
West Coral bank	1 inch "
Middle and South Coral banks	1 " "
Porbandar harbour	20 inches "
*Porbandar and Navibandar	4 " "
*Cannanur to Mahe	1½ " "
*Plans of Cannanore and Tellicheri	3 " "

* Photo-zincographed for local use.

The "Investigator" left Bombay harbour on the 20th October, and after having coaled at Colombo carried some deep soundings to the Andamans. Confirmatory evidence was obtained of the existence of the ridge or plateau of 1,700 fathoms found in April 1888 about 170 miles west of the Andamans. Between this ridge and the islands there is a submarine valley of 1,900 to 2,000 fathoms, which appears to stretch up from Acheen; on the west

side of the valley the water appeared to be slightly colder than the normal temperature of those depths.

Arriving at Port Blair, No. 1 Boat party was landed for the purpose of making a survey of Diligent straits on the one-inch scale, while the "Investigator" visited South Sentinel island and the bank off the S.W. point of Little Andaman, both of which were sounded.

Before proceeding to the Orissa coast, deep soundings were taken across the bay. The Bay of Bengal proved to have a regular decline towards its mouth, the Andaman and Nicobar ridge forming its eastern boundary (the sea east of the Andamans being a separate basin); there is slightly deeper water nearer the coasts than in the centre, and the depth falls very suddenly from the 100-fathom line off the Sunderbunds to the 900-fathom line. If we take the slope of the bed of the bay between the 1,100 and 1,400 fathoms contours as being the true gradient of its fall, unaffected to any great extent by the detritus from the rivers, and carry this gradient, which is only 1 in 396, northward, we find that it brings the bed of the bay up on a level with its surface only when it reaches the foot of the Himalayas.

The survey of the Orissa coast was begun at the mouth of the Devi river, and first carried to the northward for 24 miles. This survey was on the one-inch scale, and was afterwards carried by the "Investigator" along the coast for a total distance of 199 miles, operations being greatly helped and expedited by the marks erected by the land surveyors. The mouth of the Devi river, the anchorage at Puri, and Gopalpur anchorage were also charted on the four-inch scale.

During 1889–90 the operations were carried along the Ganjam coast to the south of Gopalpur. A survey of the Coco Islands was also commenced during the same season, as well as an examination of the Bassein River and its approaches, by the boat party under Lieutenant G. S. Gunn, R.N.

The Report for 1888–89 was the last submitted by Commander Carpenter, R.N., and in it he took the opportunity to draw up a brief review of past work, as well as a forecast of future operations. More than seven years had elapsed since the "Investigator" had made her first surveying trip, and in that time she had run some 44,000 miles, of which just half were actual lines of close soundings taken on various surveys. The "Investigator's" boats

had, in addition to the parent vessel's mileage, run some 11,500 miles of similar soundings. This total mileage, however, was far from completing the shores of India. As a matter of fact, at that time only 1,715 miles or one-third had been charted sufficiently for safe navigation out of a total length of 5,100 miles, consequently much remained and even now remains to be done before the coasts of India can be said to be adequately surveyed.

The localities specially needing attention have been specified in a very valuable memorandum by Commander Carpenter, which is attached to the Marine Survey Report for 1888-89, and a brief notice of these requirements is here desirable, and will form a fitting conclusion to the present chapter.

The mouths of the Indus have not been examined since 1877, when they were surveyed by Lieutenant A. W. Stiffe, and are continually reported to be shoaling seaward. A re-survey will have to be done astronomically with a mark boat as a guide to the line of soundings. The original survey was made as far back as 1848-49, and the examination in 1877 was only over the most projecting portion, which, however, is that which most specially requires attention from time to time.

The Gulf of Cutch shows signs of increasing trade, and before long the ports of Mundra, Tuna, Rojhi, and Salaya creek will require charting on scales sufficiently large for harbour improvements. The gulf was well surveyed for open navigation in 1852 by Lieutenant (now Commander) A. D. Taylor,* but the plotting on the chart requires fitting in with the land triangulation.

The coast of Kathiawar from Dwarka point to Gogha in the Gulf of Cambay is fairly well shown, and an improved chart to Diu head is to be compiled, but Jafrabad, between Diu and Goapnath, requires charting on a large scale, and the whole coast needs sounding off. It was surveyed by Lieutenant Ethersey, I.N., in 1837, in a *pattimar*. The operations now called for would occupy two years.

The Gulf of Cambay is practically unsurveyed, with the exception of a portion from Bhaunagar creek down to Perim island and across to Broach, which represents about one-seventh of the whole area. The head of the gulf is shallowing up and becoming less navigable every year, and this is resulting in the banks at its

* *See* page 15.

mouth extending further seaward, and becoming more dangerous to shipping. It was also surveyed by Lieutenant Ethersey prior to 1845, and though a very creditable piece of work, considering the means at his disposal and the fierce tidal currents, the chart is now quite unreliable. The work would take three years.

The Bombay coast, from latitude 20° N. as far as Bombay, has been very slightly delineated, and the whole stretch is rocky and dangerous, but there is no immediate call for a survey, though the projecting reef near Danu, specified in the old Indian Navy Officers' Memorandum of 1862, requires examination, and as local trade increases there will be a demand for reliable charts of the small ports of call along it, while a harbour of refuge is especially needed somewhere midway between Danu and Bombay. A boat party could be employed here with advantage for four years, or it would take the "Investigator" herself about two years.

At the northern end of the Kanara coast there are about 60 miles of very rocky coast, which though well surveyed by Lieutenant A. D. Taylor in 1856, are not charted so as to meet present requirements. There is not sufficient protection here for a boat party, and the scale, to be adequate, should be two inches, which would occupy the "Investigator" two seasons. A detailed survey will soon be required from the Enciam rocks to Cape Comorin, a rocky strip of the Travancore coast some 25 miles in length. On the Tinnevelli coast the Manapand shoals require proper delineation, and with the above-mentioned bit of Travancore coast would not take more than a single season.

The Laccadive Archipelago was well plotted in 1844–48 by Captain Selby and Lieutenant A. D. Taylor, but the islands have never been properly placed in longitude. Several of the group are three to four miles out of position and should be rectified by chronometric distances. This would take two months.

On the eastern coast of India the large bay north of the Paumben Pass called Palk Straits is far from complete, the soundings being thick only in shore, while the banks which extend from Point Calimere to the north point of Ceylon are of sand and liable to change. In the event of the deepening of the Paumben Pass, an accurate survey of the banks will be required with the object of finding the best position for light-ships, buoys, &c. The small ports of Karikal, Cuddalore, Porto Novo, and Pondicherry require to

be charted on a large scale, which with other miscellaneous work would take a season.

From Madras to False Point the east coast of India was, until 1888–89, quite unsurveyed, and as beacons have been erected by the land surveyors this important piece of work could be finished by 1894. With the view of rounding off this survey, the portion between the Mahanadi river and the Palmyras shoals should be examined and the soundings carried out in a south-easterly direction to 40 fathoms. This would then join on to the survey of the Pilot's Ridge, and approaches to the Hugli, executed by the Department in 1885.

The Burma coast from 20 miles north of Elephant Point down to the Terrible Rocks has only been sketched, and many complaints are received from steamers trading up and down it. The coast is essentially rocky, and there are mud volcanoes at its south end which are liable to form new shoals. This coast would take three years to complete.

Passing over the extensive Cheduba Strait survey, we again come upon a large piece of coast 150 miles in length from Sandoway to Cape Negrais, which has never received more than a running survey, and that as far back as 1826–30. This part, until properly charted, is quite unapproachable for steamers owing to the numerous rocks and shoals that exist. But as it lies in a bight and out of the track of passing vessels, the requirement is not pressing.

The Bassein river has not been examined since 1853, and has undergone great changes, but the upper reaches which connect it with the Irawadi shift so frequently that a marine survey would be thrown away, and vessels must depend only on their pilots. The entrance should, however, be sounded, and this could be done by a boat party in one season. The Great Baragua mud flat, extending across the deltaic mouth of the Irawadi, has never been thoroughly delineated and was only sketched in during the early years of this century. In 1855 Captain Ward, I.N., made a survey of it and of the outer banks of the Sittang river, but unfortunately the drawings were lost. The Sittang river mouth, too, is a blank on the present charts, nothing whatever being known of its present channels. One season should consequently be set apart for a general sounding of the Gulf of Martaban and Sittang banks.

The coast of South Burmah from Amherst to Pakchan, a length of about 400 miles, with the exception of Yé River, Tavoy River,

and Mergui, has only been delineated by running surveys as far back as the years 1820–30. The principal trade route or beaten track of trading steamers has however been sounded out sufficiently for present purposes. As trade develops and new products are discovered fresh surveys will be required. Besides the coast proper there is an extensive archipelago, on the islands of which discoveries have lately been made of silver, lead, tin, and marble, which afford exceptional facilities for shipment. The coast proper will take at least six years to survey, and the archipelago another three years. Pakchan, the Andaman islands (at present only one-fourth surveyed), the Coco group, and the Nicobars also require attention.

Summing up these requirements it will be seen, with the present establishment, about 40 years must elapse before the coasts of India and Burma can be surveyed sufficiently for safe navigation, and by that time British India may have extended its sea-board, and other coasts may demand attention. Moreover, in 40 years time ocean traffic will probably have very much enlarged, and rapidity of transit increased, greater facilities will be required to bring produce from small ports to larger ones, for shipment on ocean steamers and there will be a gradual development of new ports and localities.

Whether it will be found expedient as well as possible to cope more expeditiously with this large field of future operations, by commissioning another surveying steamer, is a point that remains to be seen. The matter has been commended by the Secretary of State to the careful consideration of the Government of India. In any case there is clearly a very extended field of employment for the Indian Coast Survey Department for many years to come.

III.

GREAT TRIGONOMETRICAL SURVEY OF INDIA.

For more than a century and a half it has been generally recognised that a trigonometrical survey forms the most correct basis for mapping a country. The selection of sites for the careful measurement of base lines, from which one or more series of triangles are projected over the expanse of country to be mapped, and the closing of the operations on to a second base line, the final measurement of which forms a check on the accuracy of the operations—this process spreads in every direction a network of precisely defined points within which it becomes possible for the topographers to insert the details. It was General Roy who commenced the work in England towards the close of last century by the measurement of a base on Hounslow Heath in 1774, and in 1802 Colonel Mudge was engaged in the measurement of his arc of the meridian from Dunnose to Clifton. The same year saw the commencement of the actual work of the Great Trigonometrical Survey of India in the measurement of Major Lambton's base line near Madras. A graphic account of Lambton's work and a history of the subsequent triangulation under Everest, Waugh, and Walker are contained in four chapters of the "Memoir on the Indian Surveys."

In 1876, at the time that our review of these operations begins, the Trigonometrical Branch was under the control of Colonel J. T. Walker, C.B., R.E., F.R.S., Superintendent, Major-General H. L. Thuillier, C.S.I., F.R.S., being Surveyor-General of India and Superintendent of the Topographical Survey.

Extensive chains of triangulatory measurements had by that time been spread over the Indian Peninsula from the Himalayas to Ceylon, and the principal triangulation was now fast approaching completion.

The first rough topographical survey of all India was also nearly accomplished, and this naturally suggested a reduction of the establishments of the Survey. In September 1875 the first step was taken by the Government of India in deciding that the

Survey budget should be reduced from 240,000*l.* to 200,000*l.* Two topographical parties were abolished, one full party was transferred to Mysore, its cost being defrayed from the revenues of that State, and similar reductions were made in the Trigonometrical and Revenue Survey branches. These reductions, however, did not entirely commend themselves to the Secretary of State. Further information was called for, Lord Salisbury expressing at the same time his hesitation in sanctioning to the full the proposed reductions except on general financial grounds or in consequence of some recent undue growth of survey expenditure.* The Government of India replied to this in August 1876, setting forth full details of the expenditure during the previous 10 years. Even this information, however, was not conclusive. The data, in the words of the Secretary of State, gave—

no indication of any enlargement of these establishments, which may not be regarded as a reasonable result of the increased desire for improved information, such as that which it is the function of the Survey Department to furnish to other branches of the administration.

His Lordship went on in his reply† to lay stress on the general usefulness of the work of the Department:—

I continue to attach much importance to the steady progress of the construction and publication of good maps of all parts of the British provinces in India, feeling sensible that without them serious obstacles are necessarily interposed in the way of the acquisition of that complete statistical knowledge of the country, the absence of which has so long been a discredit to our administration, and the application of which is so requisite for the purpose of progressive government.

I should therefore be glad if, when the time comes for considering the details of the budget for the ensuing year, your Lordship should find yourself in a position to avoid further reductions in the grant to the Survey Department.

These were statesmanlike words and undoubtedly would have borne fruit in at least arresting further reductions. But in the meantime a grave misfortune had arisen. A famine was overspreading huge tracts of country, aggregating some 200,000 square miles, in Madras and Bombay, and 36 millions of people were in the most serious plight. It was, in fact, the most grievous calamity of its kind experienced in British India since the beginning of the century.‡ This terrible state of things and the heavy expenditure caused thereby, which, of course, were not foreseen at the time the Secretary of State's despatch was written in January 1877, made it

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* Geographical Despatch to India, No. 3, dated 24th February 1876.

† No. 1, dated 4th January 1877.

‡ Report of the Indian Famine Commission, paragraph 60.

impossible to rescind or even to modify to any great extent the scope of the orders of 1875.

It was about this time that General H. L. Thuillier, the Surveyor-General, was retiring from the service in which he had done such excellent work for five and forty years, and the Government took the opportunity to call upon his successor, Colonel J. T. Walker, to frame a scheme of re-organization of the Department. This re-organization involved an amalgamation of the three branches of the Survey, viz., the Great Trigonometrical, the Topographical, and the Revenue. Up to that time they had been virtually separate departments, each with its own cadre of officers and establishments of European and Native surveyors and its own superintendent. Originally, when the three departments were first formed, at different times, the duties which each had to perform were essentially distinct. The Trigonometrical Survey was required to furnish the basis on which all surveys of interior details were to rest, and the framework within which they were to be filled and connected together. The Topographical and the Revenue Surveys were to furnish the interior details, the former having to survey by means of plane-tabling the whole country, including Native States and British territory with the exception of the richer British revenue-paying districts, which were to be surveyed by the latter on a larger scale. In course of time, however, the duties of the three departments began to overlap and intermingle. The Trigonometrical Survey was approaching its completion, and for many years a large proportion of its surveyors had been employed on topographical work. The Topographical Survey, though originally intended for the primary general survey of India, had had to undertake in many cases detailed surveys on large scales, and the Revenue Survey had in addition to its own special functions been largely employed on the topography of hill districts on a trigonometrical basis. The duties of the three departments had thus become much intermixed, while at the same time the transfer of an officer from one department to another was a matter of such difficulty, that, from every point of view, amalgamation was most desirable. This amalgamation was not carried out without a good deal of difficulty and damage to individual prospects, coincident as it was with extensive reductions. The amalgamated cadres of officers and surveyors were at last constituted as follows:—

1 Surveyor-General and Superintendent of the Trigonometrical and Topographical Branches.

1 Deputy Surveyor-General and Superintendent of the Revenue Branch.

4	Deputy Superintendents, 1st grade.			
10	,,	,,	2nd	,,
12	,,	,,	3rd	,,
11	Assistant	,,	1st	,,
11	,,	,,	2nd	,,
12	,,	,,	3rd	,,
9	Surveyors, 1st grade.			
12	,,	2nd	,,	
16	,,	3rd	,,	
22	,,	4th	,,	
23	Assistant Surveyors, 1st grade.			
25	,,	,,	2nd	,,
27	,,	,,	3rd	,,
29	,,	,,	4th	,,

The designation of "The Survey of India" was given to the amalgamated Department, which was henceforth to be one body, its officers being held to be available for any description of survey work that might be required of them, and the whole being placed under the orders of Colonel J. T. Walker.

A brief notice of the previous services of this distinguished officer seems here called for.

Major (now General) J. T. Walker, R.E., C.B., F.R.S., LL.D., &c., succeeded to the Superintendence of the Great Trigonometrical Survey on the 13th March 1861, on the retirement of Major-General Sir Andrew Waugh; he became Surveyor-General and Superintendent of Topographical Surveys on the retirement of Colonel Thuillier on the 1st January 1878; and he held the three united posts until the 12th February 1883, when he quitted India preparatory to retirement. He had entered the corps of Bombay Engineers in 1844, served throughout the Punjab campaign of 1848–49, and had been employed for the next five years in making a rapid military survey of the Northern Trans-Indus frontier, which he carried single-handed over an area of about 10,000 square miles, from Peshawar down to Dera Ismail Khan; he served in several encounters with the hill tribes on the Trans-Indus frontier, and during the mutiny of 1857 was severely wounded at the siege of Delhi; for his military services he received three medals and three clasps, a brevet majority, and the Companionship of the Bath.

He was appointed an assistant in the Great Trigonometrical Survey on the 1st December 1853, took a share in the measurement of the Chach base line in the valley of the Indus near Attock, and for some years was conducting the principal triangulation along the Indus and on the meridian of $73\frac{1}{2}°$, and in carrying a line of levels to connect the stations of the triangulation with the sea.

In 1861, when Colonel Walker became superintendent of the Great Trigonometrical Survey, the greater portion of the principal triangulation had already been completed, and the time had arrived for determining the procedure by which the fallible values of the several angles and base-lines, as obtained by actual measurement on the ground, were to be rendered consistent, and final values were to be determined for the lengths and azimuths of the sides of the triangles and also for the latitudes and longitudes of the stations, which is the ultimate object of all first-class triangulation. Already provisional corrections had been applied to the angles of certain chains of triangles directly connecting base-lines for the linear error generated between the base lines, whereby the length of one base, as computed through the triangles from the other, was brought into accordance with the measured length. But this was only a small part of the requisite reductions for general consistency. The triangulation being formed of a large number of meridional chains tied together by a few longitudinal chains—forming sections somewhat resembling a gridiron in shape—presented a large number of circuits; and at the closing side of each circuit two values were forthcoming not only of the length of the side but also of its azimuth, and two values were also forthcoming of the latitudes and longitudes of the stations at its extremities. Thus three geodetic errors—as they have been called—had to be recognised and disposed of by a process of dispersion throughout the angles, as well as the linear error; and the question arose, and a most embarrassing question it was, as to how the requisite angular corrections to produce consistency throughout could be legitimately computed.

The procedure adopted was to form equations of condition expressing the errors of the angles in each circuit as unknown quantities in terms of the closing error of the circuit, for the three geodetic as well as the linear errors. In forming the geodetic equations—now done for the first time in any survey—it was found that the co-efficients of the unknown quantities in them were greatly

more difficult to determine than the co-efficients in the linear equations, for they consist of summations of series of terms from the commencement of the circuit up to the position of the angle whose error is the unknown quantity, whereas in the linear equations the co-efficients are merely the co-tangents of the angles. The solution of the equations was effected by Gauss's method of minimum squares, in which every unknown quantity is given the weight due to the facts of observation of which it represents the error. The number of triangles in each circuit was so great that every equation usually contained at least a hundred unknown quantities and often many more, and thus the simultaneous solution of any considerable number of circuits would be a matter of enormous labour, requiring every precaution to ensure accuracy in the execution of so large a mass of interdependent calculations. It was found practically impossible to undertake the simultaneous solution of the whole of the principal triangulation of India; the triangulation was therefore apportioned into five sections, of which the dividing lines were the two longitudinal chains of triangles, one connecting Karachi with Calcutta, and the other connecting Vizagapatam with Bombay, and also the portion of the central meridional chain of triangles called the Great Arc, which lies between the parallels of 18° and 30° Of the sections thus obtained, the four northern ones were of a quadrilateral form, and were called the North-East, North-West, South-East, and South-West Quadrilaterals, the directions having reference to certain points common to all the four sections at their convergence in Central India, namely, the Sironj base-line, which was the adopted origin of the linear element of the survey, and the Kalianpur Observatory, the adopted origin of the geodetic elements of azimuth, latitude and longitude. The fifth section embraced the whole of the Peninsula to the south of a line from Bombay to Vizagapatam, and, being triangular in form, is called the Southern Trigon. Each figure presents an enormous amount of simultaneous interdependent calculation, greater than had ever been executed in any survey, or probably in any investigation whatever.

Of these sections of the triangulation the North-West, North-East, and South-East Quadrilaterals were reduced, and the final results printed and published at the head quarters of the Survey in Dehra Dun, by Mr. Hennessey and other officers directing the computing staff, under the immediate superintendence of General Walker. The results are contained in Volumes II. to IV. and VI.

to VIII. of the Account of the Operations of the Great Trigonometrical Survey. Of these volumes, nine in all—of which No. I. is on the Base-lines, No. V. on the Pendulum Operations, and No. IX. on the Longitude Operations—were published under Colonel Walker.

The principal triangulation of the Indian Survey was designed, from its commencement, to furnish data for employment in the determination of the figure of the Earth. The central chain, executed by Colonels Lambton and Everest, which extends from Cape Comorin to the Himalayas, has several stations at which astronomical observations of the latitude were taken to convert it into a geodetic arc, and it is a most valuable arc, and has been employed in all the latest and best investigations of the Earth's figure. But east and west of this central chain there were several other meridional chains when the triangulation was completed, some of them of an accuracy at least equal to and perhaps greater than that of the Great Arc, and these only required to have the latitudes of certain of their stations determined astronomically to become valuable meridional arcs for geodetic purposes. Moreover, a further contribution to geodesy became practicable as soon as a sufficient number of telegraph lines had been run over the country, by connecting certain of the trigonometrical stations with those lines, and then determining the differences in longitude between the stations telegraphically. Colonel Walker obtained a supply of new instruments for these observations, and a large number of astronomical latitudes and differential longitudes were observed under his directions, and employed by Colonel Clarke, R.E., C.B., of the Ordnance Survey, in his latest investigations of the earth's figure, published in his work on Geodesy. Much of this work, however, still remained for completion on Colonel Walker's retirement, but the principal triangulation of all India proper was completed, and the greater portion of it had been finally reduced.

Colonel Walker also initiated the pendulum operations, which were completed under his superintendence, and the tidal and levelling operations, which are still in progress.

In 1864 he went to Russia to make the acquaintance of the officers at the head of the Russian Topographical Department, and for several years he was indebted to them for copies of their latest maps of regions in Central Asia, which he employed in the compilation of the successive editions of his well-known map of Turkestan. He also did much to advance the operations of the

celebrated native explorers who have obtained so much new geography in Trans-Himalayan regions.

On being appointed Surveyor-General, Colonel Walker proceeded to carry out the amalgamation of the three branches of the Survey referred to above.

Colonel Walker held the Surveyor-Generalship until 1883, when he was succeeded by Colonel George Charles De Prée. The latter officer had entered Addiscombe in 1848, and was appointed Second Lieutenant of the Bengal Artillery in 1850. He served with the Pegu Field Force in the following year, and examined the Tonghup pass between Arakan and Burma, and reported on its practicability for elephants. For this he was thanked by Lord Dalhousie, the Governor-General, and he also gained the Pegu war medal. In 1854 he joined the Survey Department and was deputed to take up topography in Ganjam, where he worked for many years, being afterwards attached to the contiguous survey of the Chota Nagpur Division. On the disbanding of No. 4 Topographical Party (*see* p. 74), he was placed in charge of No. 7 Party (Rajputana and Simla). He officiated as Surveyor-General in 1883–84, and in the latter year was confirmed in the appointment, which he held up to his death, in Jersey, on the 18th February 1887. He was a talented and indefatigable officer, and his early death was undoubtedly due in great measure to the inclement and unhealthy tracts in the eastern part of the Peninsula where he had so long and energetically laboured. He was succeeded by Colonel H. R. Thuillier, R.E., (son of the former Surveyor-General of that name) who obtained his commission in 1857, and whose good services have admirably sustained the traditions and reputation of the Department.

During the year 1876–7, at which period our review of these operations begins, three parties were engaged on principal triangulation, on the Madras Coast Series, the Eastern Frontier Series, and the Eastern Sind Series, and two parties in the Assam Valley and British Burma on secondary triangulation. The primary object of the Madras Coast Series was the completion of the principal triangulation in Southern India by a regular series between Madras and Cape Comorin, with a branch series viâ Palk straits connecting Ceylon with India. Triangulation had been carried into this region by Colonel Lambton in the beginning of the century, but on leaving the hills of the central peninsula and entering a vast plain covered with trees and vegetation, it met with difficulties which the early appliances of the survey were inadequate to

surmount and which necessitated the stoppage of the operations. A large blank in the triangulation thus remained to be filled in. The Madras Coast Series (under the temporary direction of Captain T. T. Carter, in place of Colonel Branfill) started from Southern Tanjore and worked northwards, so as eventually to effect a junction with the Madras Longitudinal Series at its eastern extremity. The country was unfavourable for triangulation, being flat, with innumerable groves of valuable trees; the villages were numerous, and each covered much ground, and owing to the want of roads locomotion was by no means easy. The famine, too, which was raging in Southern India during the season, made the question of supplies a difficulty, prices being excessively high, and the villagers occasionally disinclined to supply food at any price. The country traversed by the party skirts the coast of South Tanjore for some fifty miles along the north-western shore of Palk straits (the Sinus Argaricus of Ptolemy), and lies between the deltas of the Vaigai and the Cauvery rivers.

In the following season the triangulation was carried by Colonel Branfill across the paddy swamps of the Cauvery delta into the valley of the Coleroon. The lofty tower of the Provincial College at Kumba Konam afforded an excellent station, which greatly facilitated the passage of the delta. An approximate connexion with the levels of the South of India Railway was effected, and seven of Colonel Lambton's old stations were identified and connected. An interesting note on the physiography of the Cauvery delta, together with a list of the proper names of stations and places with root meanings and notes on their characteristics, was compiled by Colonel Branfill during the season and published by the Asiatic Society of Bengal.

Next season (that of 1878–9) saw the party working across the alluvial flats of the Coleroon, Vellar, and South Pennar rivers, and it was not till the hillock and rock-studded plain of the Carnatic was reached that the ground became favourable for triangulation. The great Siva temple of Gangaikondapuram, in the north-east corner of the Trichinopoly district, was visited and described by Colonel Branfill, and his paper thereon was also published in the journal of the Asiatic Society of Bengal.

The operations of this party were brought to a conclusion in the year 1879–80 by the measurements of three polygons between Pondicherry and Madras. Secondary chains of triangles were carried from the main chain to fix the positions of the lighthouses

at Pondicherri, Negapatam, and other distant points, and in course of this work recourse was very frequently had to the lofty temples called Gopurams, the temporary conversion of which into theodolite stations was successfully negotiated by the Assistant Surveyor, Mr. Potter. The principal triangulation being finished early in the season, Colonel Branfill proceeded to the west coast to connect the secondary triangulation which Colonel Lambton had brought up from Cape Comorin over the hills of Travancore and Cochin to Ponani, early in the present century, with the secondary triangulation of the Malabar minor series. Colonel Branfill's operations closed with certain observations for the better connection of the triangulation on which the topography of the Nilgiri Hills is based, with his principal triangulation. This completed the modern operations in Southern India, the greater portion of which fell to his share and were accomplished with considerable skill, energy, and perseverance.

The Eastern Sind Series, on the meridian of 70°, was commenced by Captain Rogers in 1876, at a side of the Karachi Longitudinal series. It lay across a country of sheer desert, composed mainly of parallel ridges of sand of considerable height with steep slopes covered with low thorn jungle; occasionally these sandhills disappear and give place to a variously moulded surface of ever shifting sand utterly devoid of vegetation called "draens." Curiously enough, wells of good water are occasionally found in these spots, the water in other parts of the desert being scarcely drinkable. The villages are for the most part built on the tops of the sand-hills, which in winter are warmer than the valleys. During 1877–78 the rains failed in Sind, and Captain Rogers was consequently despatched to carry a secondary triangulation from the western frontier of Sind into Baluchistan along the line between Jacobabad and Quetta, a series much needed for the correction of the maps of Southern Afghanistan and Baluchistan; the position of Kandahar in particular being placed on one of the best maps 15 miles west of its real position. Towards the British frontier there is a great dearth of water and vegetation, but near the hills there are ravines and watercourses, several considerable villages, and traces of much greater prosperity and population in times past, the subsequent deterioration being attributed mainly to the unsettled condition of the country. Captain Rogers laid out several triangles near the entrance to the Bolan

pass, after which he marched to Quetta and fixed the most conspicuous hills around. During the following season war broke out with Afghanistan and Captain Rogers was attached to the southern army, but Mr. Price carried the triangles up to Quetta, and Mr. Torrens extended them to the boundary of Pishin beyond. A good description of the Kachi plain lying between General Jacob's tower on the British boundary and the mountains forms part of Mr. Price's official report. The various pieces of triangulation completed by Captain Rogers and his assistants comprised the following: 1st, the series from Jacobabad to Quetta; 2nd, the series from Quetta to Khelat; 3rd, the series from Quetta to Kandahar: 4th, the triangles round Kandahar and the Khakrez valley.

It was not till near the end of the field season of 1879–80 that the work of the Eastern Sind Series was resumed, when Captain Rogers completed two double polygons spanning a direct distance of 64 miles. In the following year the series was completed by Colonel Branfill by four polygonal figures carried northwards, and closing on to a side of the Great Indus Series. A chain of secondary triangles was also successfully carried by Mr. Torrens across Central Sind to Sehwan, on the Indus, to furnish points for the revenue and topographical surveyors.

On the northern confines of India the survey of the mountainous districts of Kumaun and Garhwal (of which only a small area remained to be done) had been in abeyance during 1875–76 so as to enable the whole strength of the party to be applied to the Dehra Dun survey, which by that means was finished in that season. In 1876–77 the Kumaun and Garhwal survey was resumed under Mr. E. C. Ryall and also brought to a conclusion. The winter had been exceptionally severe, and the spring and early summer cold and wet; consequently this told much against the surveyors, whose operations had to be conducted at an average elevation of about 16,000 feet above sea-level; Mr. Ryall's highest point of observation was 19,600, while Mr. Pocock executed one plane table section at 19,000 feet. The snow-line was much lower than usual, and owing to the inhabitants being thereby detained in their winter homes long beyond the ordinary time, supplies were very difficult to obtain. Mr. Ryall's triangulation is described below, p. 50. To Mr. J. Peyton was entrusted the topographical survey of the Byans valley, but here again the exceptionally unfavourable weather proved a great obstacle to work. In July there were only five days of clear blue sky, when the mountain features could be delineated,

and in the Kuti Valley, *behind* most of the great snow and rain collecting mountains, the weather was seldom fine for more than a couple of hours in the morning. The Byans valley communicates with Tibet by three routes, the principal and earliest open to travellers being called the Lipu Lek pass; in moderate weather this is a very easy pass. There are seven villages in the valley, all facsimiles of each other, but with the exception of some half-dozen houses built in the style of Swiss chalets, they all are small and low, the building material being furnished by the cedars of the adjoining ranges. The Bhotea inhabitants of these lofty regions are a race of sturdy hillmen, with no caste prejudices, ready to eat game of all kinds and to drink to any extent. They are principally engaged in agriculture and breeding sheep and goats, and all their clothing is made by hand looms, the wool being procured from their own sheep. Woollen blankets and plaids of bright colours and scarfs are made by the women, who occasionally act as coolies when there is a lack of men. At Garbia, one of the largest villages of the Byans valley, the Tartar physiognomy is by no means prominent, and some of the faces were expressive and even pretty. Mr. Peyton found the men always faithful to their engagements, and many of them while in attendance on him underwent great hardships, roughing it on the cold mountain tops without shelter of any kind. To Mr. Pocock and Mr. Warwick was allotted the topography of the northern and southern portions, respectively, of the Dharma valley, which runs contiguously to the Byans valley, and in the case of the former the inclemency of the weather was equal to and the altitude even greater than in the Byans valley where Mr. Peyton was occupied. The entrance to the Milam valley is through a stupendous gorge overhung by large masses of granite precipices; the gorge is about 12 miles in length, and the road through it is for the most part a mere series of narrow steps built along the faces of steep hillsides or rugged precipices; where these steps cannot be made planks leading from one ledge of a precipice to another are laid across. The mountains here are composed of three different kinds of rock, the lowest formation is granite, of which all the most lofty peaks are composed; the second is hard slate; and the third and highest is a hard crystallised limestone. At the village of Milam* the valley splits into two; the one to the west is occupied by an

* This is the village where the celebrated explorers Nain Singh and Kishen Singh were both born and brought up. *See* page 151.

extensive glacier, the other might be called a narrow gorge, extending up to the very watershed line on the Unta Dhurra pass, below which lies a glacier four miles in length. Owing to this glacier the Unta Dhurra pass is the most difficult of all the passes in Kumaun and Garwhal.

Mr. E. C. Ryall succeeded in extending the Milam series of triangles (originating from a side of the Kumaun and Garhwal survey) up to the frontier of Hundes—which is the name of the S.W. province of Tibet—and then for some distance across the frontier, whereby he was able to fix the positions of a large number of peaks in Tibetan territory.* The severity of the winter had caused the routes to be blocked up with snow; but though this may have deterred ordinary travellers, the Tibetan officials were on the alert, and soon after Mr. Ryall had crossed the frontier his presence became known to them. By informing them, however, that his object was to survey the northern limits of British territory, which he found it impossible to do from the south, he succeeded in satisfying them, and was allowed to proceed. Mr. Ryall was enabled to fix a large number of snowy peaks across the Sutlej, including the remarkable needle-like peak of Leo Porgyal situated at the point where the British frontier crosses the gorge of the river, the sacred Kailas, and other lofty peaks at the head of the Manasarowar lakes and to the east. The triangulation accomplished was sufficient to furnish bases for a detailed survey, if one should ever be desirable. The province of Hundes or Nari-Khorsam occupies the upper basins of the Sutlej and the head waters of the Karnali river. It is a most desolate region, the only trees being poplars, and these being found only along the lower banks of large streams. One of the most important places is the military fort of Taklákhar (Tiger's fortress), which is garrisoned by about 100 men and is close to the Nepal frontier. It is in reality a huge mound, the dwellings being excavated in the centre and the sides loopholed for defensive purposes. Within are said to be vast stores of grain and ammunition, the former being subject to no deterioration owing to the extreme dryness of the atmosphere. Taklákhar was the last post occupied by the Dogras in their disastrous invasion of Hundes, when Zorowar Sing's Indian army of 6,000 men was routed by the Chinese and perished miserably by the sword and by the frost on

* *See* special report attached to Surveyor-General's Report for 1877–78. Some interesting particulars are also given in the Trigonometrical Survey Report for 1876–77.

the 12th December 1841. The people of Hundes (called Hunias) are of Tartar origin, having the well-known leading ethnological characteristics of that race. They own large flocks of big, long-fleeced sheep, and herds of cattle and Tibetan goats, as well as a few yaks. There are five principal passes leading from Hundes into British territory, and the traffic over them is carried on between the 15th June and the 15th October. The passes, however, are not declared open till the authorities have satisfied themselves as to the absence of epidemics in the Ghats, the effect of small pox, &c. on some occasions among a people so indifferent to cleanliness having been terrible. Shawl wool is taken in large quantities to Amritsar and other places in the Punjab, while sheep's wool is also largely exported to the Himalayas, where it is made up into blankets and serges.

In the following year Mr. T. Kinney was despatched up the Bhagirathi valley to supplement Mr. Ryall's observations in the direction of the Nilang valley and the Tsaprang district of Hundes. The Bhagirathi forms the westernmost source of the Ganges, and the gorge through which the Nilang valley is entered is terrific in aspect; snowy peaks, from 20,000 to 21,000 feet in height, towering overhead, while the stream flows 10,000 feet below, walled in by sheer precipices sometimes 3,000 feet in height. The description given by Captain Hodgson in 1817* fully bears out Mr. Kinney's more recent account. Owing to the Tibetan frontier officials having been sharply censured by the Governor of Gartok (who has supreme authority over the province of Hundes) for allowing Mr. Ryall to cross the frontier the year before, Mr. Kinney was unable to do much more than fix some of the Tibetan peaks from the crest of the watershed, some 19,000 feet in height. The cold was intense throughout, and as the party were forced to encamp at least 4,000 feet below, much time was spent in travelling to and fro, and the out-turn of work not so great as it would have been under favourable circumstances.

The secondary triangulation in the Assam valley was carried on by Lieutenant Harman, in 1876–77, with his customary energy, notwithstanding the unfavourable weather, incessant rains flooding the nullahs and turning the forest paths into streams of mud and water, which brought out myriads of leeches, to the great discomfort of the party. Huge india-rubber trees had often to be felled, though

* *See* Asiatic Researches, Vol. XIII.

one, 112 feet in height, was usefully converted into an observing station, enabling a connexion to be established with the triangulation of Lieutenant Woodthorpe, who was carrying on a topographical survey in the neighbourhood. The work of the season extended over a distance of 53 miles, along the banks of the Brahmaputra to within a few miles of Sadiya. During the following season (1877–78) endeavours were made to extend the triangulation of the region between the Subansiri and the Dihong, so as to ascertain which of the two formed the continuation of the Sanpo river of Tibet. As it was practically impossible to venture far across the frontier, Lieutenant Harman was directed to measure the discharges of the Subansiri, the Dihong, the Dibong, and the Bramaputra in order to try and solve the question by ascertaining the magnitude of the volume of water in each river, and thus obtaining indirect evidence on the question at issue.

In company with Captain Woodthorpe, Lieutenant Harman proceeded to the Miri Hills, between the Subansiri and Dihong rivers, and succeeded in sketching about 1,500 miles on the half-inch scale. This included a portion of the Dihong river, higher than any previously surveyed, but not sufficiently high to show whether the stream is the continuation of the Sanpo or not. He next commenced to measure the river discharges, taking observations of the following:—(1) the Subansiri river; (2) the Brahmaputra, at a point three miles from Dibrugarh and below the junction of the Dihong and Dibong rivers; (3) the united stream of the Dihong and Dibong rivers, one mile below their junction and one mile above their junction with the Bramaputra; (4) the Dibong river, at one mile above its junction with the Dihong and half a mile below the junction of the Sensri river with it; (5) the Brahmaputra river, about nine miles above Sadiya and half a mile below the junction of the united stream of the Tengapani and Noa Dihing rivers; and (6) the united stream of the two latter rivers, at about 200 yards below their junction.

The full details of these interesting operations, including the sectional measurements and the calculation of discharges, have been published by the Asiatic Society of Bengal.* The general effect is to show that the volume of water in the Dihong is from two to

* *See* J. A. S. B., Vol. XLVIII., Pt. 2, No. I., 1879. The measurements, in connexion with the earlier ones by Bedford and Wilcox, are also discussed in General Walker's paper on the Hydrography of S.E. Tibet (*see* Proceedings Royal Geographical Society, p. 581 of 1888).

three times as great as that of the Subansiri, and that the former is much more likely to be the continuation of the Sanpo than the latter.

The secondary triangulation in Burma consisted in 1876 of chains projected from the Eastern Frontier Series in various directions, one being from Myanong to Cape Negrais, (2) one from Prome to Thayetmyo and Tonghu, and (4) a chain to meet (2) in the neighbourhood of Tonghu. The country through which these operations had to be carried on was difficult, the hills being flat-topped, densely wooded, and from their similarity difficult to distinguish apart. The difficulty of obtaining labour, too, was considerable, as the Burmese coolies strongly object to being absent from home for more than a day or two. In the following season (1877) Mr. Beverley was instructed to select suitable sites for two lofty beacons which it was proposed to erect on the coast line abreast of the Krishna shoal, the lighthouse on which had mysteriously disappeared, whether blown over in a storm or demolished by the collision of a vessel was unknown. Strenuous efforts were made to extend the triangulation towards these beacons during the year 1878–79; but in consequence of the great difficulties encountered, owing to the country being quite uninhabited and covered with dense forest and jungle, through which it was almost hopeless to attempt to cut openings for the rays, the attempt to triangulate was abandoned, and instead thereof a traverse survey was carried to the beacons along the best paths that could be found.

At the close of the season 1875–76 the line of principal triangulation called the Eastern Frontier Series had been brought down to the vicinity of Tavoy, whence, during 1876–77, it was carried forward in all a distance of 92 miles, first by Mr. H. Beverley and afterwards by Captain J. Hill, R.E., who assumed command. For the extension of the triangulation southwards it was necessary, during the ensuing season, to have a station on the group of islands known as the Middle Moscos, and another on the Southern Moscos. The country traversed on the mainland was very like that of the previous season; a thick impenetrable jungle, covering plain and mountain alike, and offering great obstruction to the elephants, which had often to be brought to the stations by tediously circuitous routes. The trigonometrical measurements were advanced a distance of 65 miles; the position of the town of Tavoy was fixed, as well as that of the "Three Pagodas," an important and well-known mark

on the boundary between Siam and Tenasserim. All the officers suffered more or less in health after their exposure and privation in the Tenasserim jungles, and the want of a sanitarium in Burma to enable men to recruit before entering the duties of a fresh season was much felt.

This series had now reached a point about 35 miles south of Tavoy, from which the direct distance to Bangkok, the capital of Siam, was only 90 miles, while the distance round the coasts was fully 2,000 miles. As a check on the marine surveys it was very desirable for a chain of triangles to be carried across into Siamese territory, and to this the King of Siam readily assented. Singularly enough, the tract of British territory lying up to the Siamese boundary, though only 42 miles in width, proved the most difficult piece of all, the hills (composed chiefly of metamorphic rocks) being generally flat with no commanding points, while the dense tropical vegetation and unusually long rainy season of 1878 were further obstacles to speedy progress. Once across the frontier the country suddenly became more favourable, and with the ready co-operation of the Siamese officials good progress was made up to within 25 miles of Bangkok, the remaining portion being continued by Captain Hill late in the following year, and completed by Mr. McCarthy at the beginning of the season 1880–81. Mr. McCarthy also determined the position of the six next most important towns in Siam; one of the stations selected was part of the celebrated Phra Pratom pagoda, the largest in Siam. The outside circuit of its enclosure is 3,251 feet. Within this enclosure, which is cloistered and turreted, are other cloisters, temples, and belfries built on successive plateaux, while from the centre of the highest a great bell-shaped spire springs to the height of 347 feet above the ground. Besides these places the positions of several hill peaks on both sides of the head of the Gulf of Siam were determined, compass sketches made of several of the chief rivers and canals, and a plan of Bangkok prepared on the scale of four inches to the mile.

In November 1880 Mr. McCarthy was requested by the British Vice-Consul, Mr. Newman, to accompany a Siamese telegraphic expedition then about to start for the Natyadung pass, on the British frontier, about 55 miles higher up than the Amya pass, by which the survey party had crossed into Siam. The whole route up to the former pass was measured with cane ropes, and Mr. McCarthy

was also enabled to get bearings to fresh peaks and to affix the names to some already observed. He returned to Moulmein on the 13th April 1881, having been employed on field duty nearly eighteen months, and having won good opinions in his dealings with the Siamese officials and natives.

The extension of the Eastern Frontier Series or chain of principal triangulation down into lower Tenasserim, with a view to the measurement of a base-line at the southern extremity of British Indian territory, was taken in hand by Mr. H. Beverley in November 1879. But the ill-health from which, in spite of a very strong constitution, he had suffered for some years, proved fatal and he died on the 22nd June. He had served 25 years in the Department, and notwithstanding the malarious and difficult tracts in which he had often worked his labours were assiduous and successful.

The selection of a suitable site for the measurement of a base-line was a difficult matter, but eventually a good spot was discovered in the Mergui township, Mergui island, beyond the range of the numerous creeks which penetrate inland from the sea. Lastly, but not leastly, supplies for the numerous surveyors and their followers were here easily procurable. While Mr. Potter, Assistant Surveyor, was constructing the principal stations around the base-line, and clearing the rays between them, Captain Hill was completing the remaining triangles between Tavoy and the base-line and connecting his heights with the sea-level for verification. Extraordinary difficulties were experienced from the haze, which was so dense that the shipping people and fishing population were unable to carry on their usual calling. The meteorological observations throw very little light on the cause of this peculiar haze. It generally commences about the middle of January, with north-east or easterly winds, and rain seems to have no effect upon it; with south-west or western winds it clears. The natives add that exceptionally hazy seasons occur at intervals of about five or six years.

The part of Mergui chosen for the base-line appears to have been more thickly inhabited in former times than at present. Many old pagodas, some in ruins, are scattered about. A number of Mussulmans, chiefly descendants of men from India and the Straits who have intermarried with Burmans, have taken up their residence in the place; they are increasing steadily, and supplanting the original Burmans. The Mergui archipelago, consisting of

thickly-studded islands, interspersed with shoals and rocks, enjoys a salubrious climate, and the scenery is beautiful. Many of the islands are peculiar and interesting; one with a central basin enclosed by walls of rock can be approached through a short tunnel open only at low water, and when the tide rises communication with the outer world is cut off for six hours. Another small flat island, called Tho Bya, has a small fresh-water lake in the centre, and until recently villages stood and fields were cultivated round the margin; but tigers came and multiplied to such an extent that they drove away the people, and the island is now deserted. With the exception of the fishing people from Mergui and the neighbourhood, the only inhabitants of the smaller islands of the Archipelago are the Selung, a small tribe of strange, timid, wild beings, without fixed abode, living almost entirely in their boats. According to Captain Hill they appear to be fleeced systematically by the Chinese, who send agents to them out into the Archipelago to barter rice at exorbitant rates for the pearls, shells (which fetch very high prices in China), bees-wax, mats, &c. which the Selung are able to supply.

During the season 1881–82 two parties were engaged in the completion of the Eastern Frontier Series and the measurement of the Mergui base, viz., that under Major Rogers (who had relieved Captain Hill), and the party under Colonel Branfill which in the previous year had been employed in completing the Eastern Sind Series. During the first half of the season these parties worked independently of each other; Colonel Branfill's in connecting the principal triangulation with the base-line and executing the necessary preliminaries for the linear measurement; Major Rogers's in extending the principal triangulation southwards and making a reconnaissance of the islands of the Mergui archipelago, with a view to the future extension down to Singapore. With the aid of the Indian Marine steamer "Celerity," by which communication was much expedited, the most was made of the brief observing season—barely two months—and by the end of January all hands were engaged in the measurement of the Mergui base-line under Colonel Branfill. The base is only about 3·4 miles in length, or rather less than half the average length of the previous Indian base-lines (that at Cape Comorin alone excepted); but suitable ground for a longer base could not be found anywhere on the coasts or islands of the Archipelago.

The actual measurements and comparisons of the compensation bars with the standard of length occupied 24 days, and the value of the length of the base-line, as determined by calculation through the triangulation, which consists of a chain of polygonal figures nearly 1,000 miles in length, proved to be only 3·4 inches, or 1 inch per mile, in excess of the measured value.

With a view to determine the height of the base-line above the sea a line of spirit-levels was carried from one end down to the coast—where arrangements were made for erecting a tidal station. Astronomical observations for the determination of the latitude and the azimuth were taken at four of the stations of the principal triangulation in the vicinity of the base-line, and the mean differences between these observations and the latitudes and azimuths geodetically computed from Kalianpur—Colonel Everest's station of astronomical origin—were 8·2″ in latitude and 11·2″ in azimuth; but the theoretical probable errors generated in the course of the triangulation between the origin at Kalianpur and the terminus at Mergui are less than $\pm 1''$ in latitude and $\pm 3''$ in azimuth; thus the discrepancies between the observed astronomical and the deduced geodetic results at Mergui are probably due mainly to the influence of local attractions in deflecting the plumb-line at the initial and terminal astronomical stations.

Latitude observations were also made at Moulmein by Major Rogers, and the same officer also inspected the working of the tide-gauges at Moulmein, Amherst, Rangoon, Elephant point, and Port Blair, and then proceeded to Poona to relieve Major Hill of the charge of the tidal and levelling party. Thus the supervision of the calculations for the reduction of the principal triangulation and the astronomical observations mainly devolved on Colonel Branfill, who, having brought all the work to a satisfactory completion and handed it over to Mr. Hennessey, at the computing office of the great trigonometrical survey in Dehra Dun, proceeded to Europe on furlough. The triangulation parties were then broken up, most of the officers being transferred to topographical surveys, while the native establishments were reduced and transferred to the new secondary triangulation party and the Nepal Boundary survey.

The chain of principal triangles known as the Eastern Frontier Series had thus been brought down from Assam through Arakan

and British Burma into Tenasserim, and closed on to a base-line of verification in Mergui, near the southern extremity of the British territory east of the Bay of Bengal. Thus the principal triangulation of all India had been completed on the lines originally marked out by Colonel Everest and sanctioned by the Honourable Court of Directors of the East India Company. A brief retrospect of the history of this great undertaking, epitomized from General Walker's excellent account thereof, may be here given.

The Great Trigonometrical Survey of India originated in a so-called "mathematical and geographical survey," which was commenced in Southern India, in the year 1800, by Major Lambton of H.M.'s 33rd Regiment of Foot, on the recommendation of the Honourable Colonel Wellesley, afterwards Duke of Wellington. Its object was, in Major Lambton's words, to "determine the exact "positions of all the great objects that appeared best calculated "to become permanent geographical marks, to be hereafter guides "for facilitating a general survey of the peninsula;" and as at that time the elements of the figure of the earth were not known with sufficient approximation to enable the latitudes and longitudes of the "great objects" to be computed with accuracy from the data of the triangulation, Major Lambton pointed out that his intended survey would, in the interests "of general science involve many "more objects than that immediately appertain to geography," and that portions of the triangulation would have to be executed with the utmost possible precision, and be supplemented by astronomical determination of position, with a view to the requirements of geodesy.

Between the year 1800 and 1825 the operations consisted of a network of triangulation over Southern India, grounded on, and verified by, several chain-measured base-lines, through the middle of which a principal chain of triangles was carried in a meridional direction, from Cape Comorin up to Sironj in Central India. This chain formed the southern portion of what is now known as Lambton and Everest's Great Arc. Its angles were measured with greater care than those of the collateral network, and at certain of its stations astronomical observations of the latitude were taken for the determination of the included minor arcs of amplitude. Colonel Lambton died in 1823, and was succeeded by Colonel Everest, who found no difficulty in obtaining *carte blanche* from the Government

of India and the Court of Directors for a new instrumental equipment, much superior to what had hitherto been employed. During his absence from India a small party of surveyors was engaged in carrying a longitudinal chain of triangles eastwards from the point reached by the Great Arc in Central India to Calcutta.

On his return from Europe in 1830, Colonel Everest recommended the abandonment of the network system of triangulation, and the substitution instead of what he called the "gridiron" system, consisting of meridional chains which were intended to be constructed at intervals of about one degree apart, while the longitudinal chains would follow the parallels of Calcutta, Bombay, and Madras, and thus run at intervals of from five to six degrees apart. The external chains of the gridiron were to follow the British frontier lines and the coast lines. The entire triangulation was to be grounded on base-lines measured with the Colby apparatus of compensation bars and microscopes—in terms of a fixed standard of length—which were to supersede the old base-lines that had been measured with chains of comparatively rude construction and of uncertain length. This programme of operations was approved by the Government of India and the Court of Directors, and it has furnished the guiding lines on which the principal triangulation has been executed during a period of almost exactly half a century.

For convenience of treatment in the final reduction, the whole of the chains situated within the limits of India proper have been grouped into five sections. Four of these are roughly four-sided in outline and are respectively called the North-East, North-West, South-East, and South-West Quadrilaterals, names in which the cardinal points have reference to the Kalianpur Observatory in Central India, which Colonel Everest adopted as the origin of the operations subsequent to 1832. The fifth is three-sided, and is called the Southern Trigon, and embrace the southern portion of the peninsula, below the parallel of Madras. The North-East Quadrilateral was completed first of all, and here it will be seen, on reference to the Chart of the Principal Triangulation, that the meridional chains of triangles lie at intervals of about one degree apart, as originally designed by Colonel Everest. But in the sections subsequently executed the intervals between the meridional chains were materially increased, as the minor triangulations which in course of time came to be executed by the topographical surveys were of such accuracy that a smaller amount of principal triangulation was

found to suffice for all geographical requirements, and more was not wanted for geodetical requirements. An additional meridional chain might have been constructed on the meridian of 84° within the South-East Quadrilateral, and it doubtless would have been constructed but that before it could be commenced a network of excellent topographical triangulation had been thrown over the entire area which is included between the collateral principal chains, and nothing more was wanted. Similarly in the Southern Trigon, the execution of a chain of principal triangles along the west coast from Cape Comorin to Mangalore was desirable for symmetry, co-ordinately with the chain on the east coast from Cape Comorin to Madras, but it was not wanted for geodesy. For geographical purposes the Malabar coast series of secondary triangles was amply sufficient. It had been mostly executed by Major Lambton, and it stood connected with the modern operations. Major Lambton had not, however, attempted to throw his triangulation over the broad belt of plains on the east coast, which is covered with trees and obstacles that he had no means of surmounting. Thus a chain of principal triangles has been extended of late years over those plains, and has furnished a base from which a branch chain of triangles has been carried across the Paumben straits to the Island of Ceylon, in order to connect the surveys of India and Ceylon.

For geodetic purposes the amount of principal triangulation which has been executed has been pronounced to be ample. The first measurement of the sections of the Great Arc between Cape Comorin and Sironj was accomplished with instruments far inferior in accuracy to those with which the liberality of the Court of Directors furnished Colonel Everest in subsequent years, and being deemed of insufficient accuracy for geodetic requirements, its revision was directed to be undertaken as soon as might be consistent with the need of triangulation for geographical purposes in other parts of India. The northern section, from Sironj down to Bidar, was indeed revised under Colonel Everest's superintendence in 1838–39, but the revision of the southern sections — Bidar, Bangalore, Cape Comorin—was postponed for several years, and was eventually accomplished during 1869–74.

The longitudinal series, from Sironj to Calcutta, was also revised, as it was originally executed with very inferior instrumental

means, and it happens to be the most important of all the great chains of triangles, because it furnishes bases for no less than 14 meridional chains lying to its north and south. Partial revisions have been made in other quarters of work executed with inferior instruments, which it was deemed necessary to raise to a higher standard of accuracy. Outside the limits of India proper the more recently completed chain of triangles called the Eastern Frontier Series is a valuable contribution to geodesy as well as geography.

The whole of the triangulation rests on ten base-lines which have been measured with the Colby apparatus of compensation bars and microscopes, which was constructed in England under Colonel Everest's superintendence. The relations of the length of the Indian standard to the principal European standards of length have been very exactly determined. Considerations of symmetry would suggest the introduction of an additional base-line near Bombay, on the same parallel as the Bidar and Vizagapatam base-lines, and measured with the same apparatus. But it so happened that a chain base-line had been measured on the Karleh plain, near Bombay, in the year 1828, by Captain Shortrede, the calculated value of which, through the longitudinal series from the Bidar base-line, agrees very closely with the measured value. It was commended by Colonel Everest, who, however, some years afterwards, in 1848, made preliminary arrangements for the measurement of another line in the neighbourhood with the Colby apparatus, but he did not carry out this project. Eventually the idea was abandoned, as the distance from the Bidar base is comparatively small, and no material advantage at all commensurate with the labour and expense would be derived from the measurement of a new base; for to measure a base-line with the Colby apparatus occupies two full-strength trigonometrical parties for an entire field season, unless there happens to be other employment for the survey officers in the neighbourhood of the base. There is some uncertainty as regards the unit of length adopted by Captain Shortrede in measuring the Karleh base, consequently this base has not been employed in the final reductions, though no new base has been measured.

Thus the great work of the principal triangulation of India became an accomplished fact. Commenced in 1800, under the auspices of the Madras Government, it was carried on by Major Lambton, almost single-handed, until the year 1818, when the

Marquis of Hastings, who was then Governor-General, placed it under the direct and immediate control of the Supreme Government. Captain Everest was shortly afterwards appointed assistant to Major Lambton. In 1832 additional officers were appointed, and by the year 1840, when the geodetic operations on the northern sections of the Great Arc were completed, the *personnel* sufficed for the equipment of six trigonometrical survey parties, and this number of parties was uniformly maintained from that time onwards, until it could be gradually diminished on the completion of the successive chains of triangles. The operations have been uniformly and consistently supported by the Supreme Government, with the sanction and approval, first of the Honourable Court of Directors of the East India Company, and afterwards of the Secretary of State for India. In times of war and financial embarrassment the scope of the operations has been curtailed and establishments have been reduced, and some of the military officers sent to join the armies in the field; occasionally the civilians also have been sent to the seat of war, to be employed on survey duties. But whatever the crisis, the operations have never been wholly suspended. Even during the troubles of 1857–58 they were carried on in some districts though arrested in others. They have been uninfluenced by changes of *personnel* in the administration of the British Indian Empire, each succeeding Governor-General or Viceroy having honoured them with his support. At the close of the mutinies, Lord Canning wrote as follows of the principal triangulation and collateral topography in Kashmir to Colonel Waugh, then Surveyor-General of India :—

"I cannot resist telling you at once with how much satisfaction I have seen those papers. It is a pleasure to turn from the troubles and anxieties with which India is still beset, and to find that a gigantic work of permanent peaceful usefulness, and one which will assuredly take the highest rank as a work of scientific labour and skill, has been steadily and rapidly progressing through all the turmoil of the last two years."

and up to the last moment, the successive Government have accorded their support to the operations with equal liberality and constancy. It may well be doubted whether any similar undertaking, executed in any other part of the world, has been equally favoured and supported.

The field operations, viz., the measurements of the base-lines and angles of the principal triangulation, being completed, the next

step was the final reduction and harmonising of the results, giving to each measurement and observation its proper weight, and nothing more or less. Strictly speaking, this undertaking should have been postponed until the completion of the whole of the operations, and then all the observations should be reduced simultaneously, because every fact of observation is more or less dependent on, and connected with, every other fact. But the simultaneous reduction of the vast number of such facts acquired over all India, by many individuals and during a period of many years, was obviously impossible. Thus it became necessary to divide the triangulation of India proper into five sections, and even then the simultaneous reduction of the numerous facts of observation collected together in each group was a work of enormous labour, necessitating, as remarked by *Colonel Clarke*, C.B., of the Ordnance Survey, one of the most eminent of living geodesists, in his recent treatise on geodesy, "the most elaborate calculations that have "ever been undertaken for the reduction of triangulation." The division of the work into sections necessitated the maintenance of the results determined for the sections first reduced in the contiguous sections, when they, in turn, came to be reduced and this necessitated commencement with the section, which in all its parts was of the highest accuracy. The section of which the field work was first completed was the North-east Quadrilateral, but as many of its angles had been measured with instruments of inferior accuracy to those employed in the sections which were subsequently completed, the reductions were performed in the following order:—first, the North-west Quadrilateral; secondly, the South-east Quadrilateral; and thirdly, the North-east Quadrilateral. The reductions were commenced in the year 1869; the final results of the first section are given in Volumes II., III., and IV. of the Account of the Operations of the Great Trigonometrical Survey, published in 1879; those of the second in Volume VI., published in 1880; and those of the third in Volumes VII. and VIII. The fourth section selected for treatment was the Southern Trigon.

The stations of the principal triangulation were 3,665 in number in 1885. They have been constructed with a view to being as lasting and permanent as possible. On the plains they take the form of towers rising from 20 to 40, and even 60 feet above the ground level, and usually about 16 feet square at base, with an isolated central pillar—always of masonry—for the instruments to rest on.

On hills and mounds the central pillar is raised two to four feet above the ground level, and is surrounded with a platform of earth and stones. Mark-stones engraved with a dot and surrounding circle to define with precision the point to which the observations are referred, are inserted on the surface and at the base of each pillar. The stations are invariably placed under the protection of the local officials; they are scattered over 338 British districts and Native states, in each of which some officer is required to submit annual reports of the condition of the whole of the stations within its circle; repairs are effected whenever necessary. If the present system of protection and repairs is maintained by future generations of officials, the duration of the stations should be coeval with that of the hills and plains on which they stand, and the great work now completed will be of lasting utility.

A considerable amount of secondary triangulation has been executed *pari passu* with the principal triangulation, partly by observations from the principal stations to all the most prominent objects visible from them, as the snowy peaks of the Himalayan range, and partly by the construction of chains of secondary triangles resting on the primary chains, such as have been carried to a number of important towns and cities within the limits of the Empire, and of late years beyond these limits, to Kandahar and Khelat on the one side, and to Bangkok on the other. Much secondary triangulation, however, still remains to be executed. Until recently it was wanted on the coast lines to furnish fixed points for the marine surveys, and in localities in the interior at a distance from the nearest principal chains, where data may be required for topographical surveys. But it is chiefly wanted outside the limits of India proper, as for the extension of the Eastern Frontier Series through the Malayan peninsula down to Singapore, and to furnish a basis for the geography of Upper Burma. For the latter purpose three chains on the meridians of 94°, 96°, and 98° respectively are desirable, the two first of which would close on the chain of secondary triangulation already completed in the Assam valley, while the third might be carried still further to the north. Bangkok, the capital of Siam, having already been connected with the Indian triangulation by a chain of triangles, which was recently executed with the support of the Siamese Government.

The requirements of geodesy necessitate astronomical observations for the determination of the latitude and the azimuth, and electro

telegraphic observations for the determination of differential longitudes, at several of the stations of the principal triangulation. These have already been completed to a considerable extent. Further operations of this nature are in progress; they are carried out by the two small astronomical parties which are attached to the trigonometrical or geodetic branch of the Department, and by which all the operations that are required to render the principal triangulation fully subservient to geodetic science should be completed in the course of time. An extensive series of pendulum observations for investigations of variations of gravity and the figure of the earth, taken chiefly at stations of the principal triangulation, has been completed and connected with the groups of corresponding observations in other parts of the globe. Long lines of spirit-levels have been carried on in connexion with the principal triangulation, from the sea to the base-lines in the interior, and from sea to sea across the peninsula; they rest on determinations of the mean sea-level which have been made at the tidal stations on the coasts.*

On the conclusion of the measurement of the Mergui base-line, Mr. J. McGill and Mr. C. D. Potter were deputed in 1882-3 to carry a chain of secondary triangulation along the east coast, chiefly for the purpose of setting up beacons for the use of the marine surveys. These operations extended between Ichapur, in Ganjam, to the town of Pooree, the seat of the Jaganath temple. The country is generally well populated and prosperous, including seaports and large towns, but subject to unhealthy malarious influences. The Chilka lake fell within the area of the work; it is a vast sheet of salt water, covering 350 square miles, with numerous islands, and fed by freshets of the Mahanadi river and numerous small streams descending from the Eastern Ghats; it has one outlet into the sea by a small breach in the said ridge, and a canal connects with the port of Ganjam. During 1883–84 the measurements were carried northward along the coast of Orissa from Pooree to Balasor by Mr. A. D'Souza, and the opportunity was taken to look up the old stations of Major Saxton and Captain Depree's survey in 1858-59. In 1884-85 Mr. D'Souza worked southwards, and carried the old triangulation of the Madras Coast Series, which had stopped at Coringa, to the mouth of the Godavari. Some interesting notes on the principal coast towns and rivers of the Ganjam, Vizagapatam, and Godavari districts accompany his report on the operations. The following

* From the Surveyor General's Report for 1881-82.

seasons saw the operations advance both northwards and southwards, and in 1887–88 the entire coast triangulation from False Point to Point Calimere, in the Tanjore district, was completed. Mr. Ryall, who had assumed charge in 1885–86, had hoped to close his work on to the station of the Negapatam Minor Series, but these were found to be so inconveniently situated and so hemmed in by gardens and trees, that a carefully executed traverse, 60 miles in length, was executed, and a junction effected with stations of the Great Trigonometrical Survey.

The triangulation along the Madras coast having been thus completed in 1887–88, the following year saw the party transferred to Lower Burma for the purpose of carrying out similar work there and fixing artificial beacons, as well as natural landmarks, at convenient intervals within sight of the sea for the Marine Surveyors to base their work upon. One hundred and fifty-seven miles of triangulation of this description were completed in 1888–89, reaching from Cape Negrais to Sandoway, and about 170 miles in the following season. A commencement was also made of the principal triangulation for Upper Burma on the meridian of 97°. The series emanated from a side of the Eastern Frontier Series near Toungoo, and is destined to proceed northwards as far as Mandalay in the first instance. Owing to climatic and other difficulties, the progress during the past season was limited to the selection of two figures and the building of the observing stations at the angles, but the work was carried for 50 miles further in 1889–90, and six new principal stations were fixed. For the Marine Surveys, 35 points were fixed during the same year along a distance of 170 miles from Kutabdia light-house off the coast of Chittagong, Bengal, to Akyab, in Burma.

The series of secondary triangles emanating from the Great Indus Series and running along the parallel of 30° N. latitude, which had been commenced in the previous year to furnish a basis for future work in Baluchistan was continued for a direct distance of 115 miles to Quetta. Observations at four stations still remained to carry the series to the Khwaja Amran range.

In this province and in the other new province of Upper Burma a large field still awaits the exertions of the Indian triangulation parties.

IV.

TOPOGRAPHICAL SURVEYS.

The Topographical and Revenue Surveys serve to furnish the details required for filling up the outline supplied by the fixed points of the triangulation, the former being confined mainly to the Native States, and non-regulation British districts, of small importance from a revenue point of view, while the Revenue Surveys deal with the more productive and valuable tracts. As has been appropriately said, it is their function to supply flesh and blood to the skeleton provided by the triangulators. But while the Trigonometrical Survey has had to be conducted regularly throughout on a fixed plan, both the Topographical and Revenue operations have to be taken up on varying scales to suit local requirements and conditions. The standard scale of the Topographical Survey is 1 inch to the mile, but where the work has to be executed very quickly the scale is reduced to ½ or to ¼ of an inch to the mile, as in trans-frontier regions; on the other hand, in British territory it is sometimes increased to 2 inches, and generally to 4 inches for Forest Surveys. The Revenue Surveys are on scales of 4, 16, and 32 inches to the mile, and sometimes larger scales. These two classes of operations have covered the greater portion of the expanse of British India and the Native States, which have thus been, or are being, practically mapped out on the scale and in the manner most appropriate to the general purposes of administration. The accuracy of the work has necessarily varied greatly according to circumstances. Some of the earlier topographical surveys partook more of the nature of rough and hasty geographical reconnaissances, but the more recent surveys have been carried out on more rigorous principles, and with greater regard for completeness and precision. Since the close of the Punjab war in 1847, and the publication of the "Manual of Surveying for India" a few years later, by Captains Smyth and Thuillier, there has been an ever-increasing

efficiency in the methods and procedure of the surveys, and in the completeness and trustworthiness of the resulting maps.

At the close of the period dealt with in the last edition of the "Memoir," the primary topography of the larger part of India, as shown by the index map attached to General Thuillier's topographical report, had been completed, the most conspicuous blanks still remaining being the western half of Rajputana, the greater part of the North-West Provinces, the Konkans, and nearly all the Madras Presidency. The old maps of nearly all these regions had supplied material for published sheets of the Indian Atlas on the scale of four miles to the inch, but much of it was incomplete and unsatisfactory, and the re-survey and re-engraving of the less-accurately mapped tracts have consequently had to be taken up as financial and other considerations permitted. The most recent index map of the Indian Atlas shows that the Punjab, Sind, the Berars, part of Rajputana, most of the western and southern portion of the Bombay Presidency, Haidarabad, and nearly all Southern India, as well as the North-West and Lower Provinces, must be re-engraved before the Indian Atlas sheets exhibiting those regions can be held to be up to the level of accuracy befitting the standard map of India. And as in many of these tracts fresh and better surveys must precede the preparation of fresh plates, it is clear that there is abundance of employment still awaiting the Indian Topographical and Revenue Survey parties.

During the season 1876–77 nine separate parties of the Topographical Survey were at work in different parts of India. The area allotted to the operations of the Gwalior and Central India Survey covers an extensive portion of country east and south of the Rajputana desert. One of its principal duties in 1876–77 was the construction of large scale surveys of the fortress of Gwalior, the cantonments of Morar, the native city, and the Residency lands and surrounding country for the military authorities. These were superintended by Captain Charles Strahan, R.E., chief of the party, while Lieutenant J. R. Hobday carried on the one-inch work towards the west in the Native States Udaipur, Dungarpur, and Tonk in the Rajputana Agency. Part of Captain Strahan's operations lay near the great water-parting of the rivers draining east into the Bay of Bengal and those flowing into the Gulf of Cambay on the west, and the difference here observable is most remarkable, the north-east portion being very flat and quite open,

with several large towns and villages and fairly well cultivated; it forms part of the plateau of Rajputana, and is on the average about 1,600 feet above the sea; while, after crossing the water-shed the change is quite abrupt: the ground is intersected by watercourses which gradually deepen into narrow valleys, and the general fall of the face of the country shows a drop of 950 feet.

In 1877–78 the work of the party lay in the vicinity of Udaipur and east of the Aravalli mountains, a region part of which is inhabited by the notorious Bhils.* Lieutenant Hobday penetrated into one "pál" or settlement (liter. "the embankment of a tank"), where no one except Captain Conolly of the Bhil Corps had ever dared to venture. He, however, trusted the people, and was well received. The Bhil Corps appears from the accounts of Captain Strahan and his assistants to be doing excellent work among the wild denizens of these parts. Before the organization of the corps, the Bhils trusted no one, looked on all intruders as enemies, and were so incredulous of the good faith of the British that they had to be paid daily, simply because they could not believe that if they remained they would really receive their pay at the end of the month. Now there are always a number of young men waiting for vacancies to be enlisted in the regiment. Desertion is still frequent, but this is partly due to their love of home and the distances to be traversed, it being no uncommon thing for a sepoy to walk 15 or 20 miles to his home after his day's work and be back in time for parade in the morning. A great deal of topographical information respecting this country was amassed by Captain Strahan, including a detailed description of the great fort of Chitorgarh.†

During this season the party was deprived of one of its most highly-valued members by the death of Mr. H. J. Bolst, who succumbed to typhoid fever after a long illness. He had been 27 years in the Department, 17 years of which had been spent in this party, where he had rendered most useful service.

The programme for 1878–79 involved a partial diversion from the ordinary work, and included a survey of the Pachpadra salt fields (described by Captain C. Strahan in the appendix) on the 4-inch scale, and of the land adjoining the Luni River on the 1-inch scale, both

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* Some interesting details respecting the Bhils by Sub-surveyor Abdul Sobhan will be found at page 43 of the Topographical Survey Report for 1876–77.

† *See* page 101, *et seq.*, of Surveyor General's Report for 1877–78. Also pages 41 and 42 of Topographical Survey Report for 1876-77.

being in the Jodhpur State, for the requirements of the Indian Customs Department. The regular work of the party consisted of a detail survey of the city of Udaipur* and environs on the 12-inch scale, and detail survey of the neighbouring district on the 1-inch scale. A comparatively small out-turn of work was effected in the following season, but this was mainly due to the intricate character of the ground, which was likened by Major E. H. Steel (who took charge during absence on furlough of Captain Strahan) to "a petrified stormy sea." The ground to the north, whither the operations were moved in 1880–81, proved still more intricate and difficult, and the attitude of the Bhils was very threatening, insomuch so that Mr. Templeton, one of the surveyors, was warned not to return to one of the Bhil villages if he valued his life. In 1881–82 the region about Mount Abu fell within the area of triangulation, while the topography ranged over the three Rajput States of Marwar, Mewar, and Sirohi. The transfer of No. 7 topographical party from Rajputana to Burma led to its uncompleted ground being allotted to No. 1 party, which in consequence assumed the designation of the Central India and the Rajputana Survey party. In the three years 1882–85 portions of the country south-west of Erinpura as well as of the desert west of Bikanir and parts of the Sirohi, Palanpur, and Jodhpur States were mapped in detail, as well as special surveys of the Sunda and Dorra ranges of hills, and large scale surveys of Ajmere, Jaipur, Amer or Amber. In 1885–86 the triangulation was carried down to the margin of the Rann of Cutch mentioned below (*see* p. 85), while the detail survey was carried on in portions of Jodhpur and tracts adjacent to the Luni river. But at the close of that season the Rajputana party was ordered to be transferred to Baluchistan, so a large tract of this important province of British India remains unsurveyed, with no definite arrangements for its completion. The number of standard sheets unsurveyed are fifty out of a total of ninety-seven, covering nearly all the western half of the province.

The Khandesh and Bombay Native States Survey worked in two detachments in 1876–77, one being employed on the ordinary one-inch scale in the Native hilly states north of the Narbada, and the second, under Mr. H. Horst, the officer in charge, on the more

* A good description of the city will be found from the pen of Lieutenant J. R. Hobday at pages 42 and 43 of the Topographical Survey Report for 1875–76.

important two-inch survey of the revenue-paying portion of the plains of Khandesh. While surveying in the Tapti valley, Mr. Graham, Assistant Surveyor, witnessed some extraordinary examples of "sorcery" among the Bhils, such as walking through and treading on live coals barefoot without sustaining the slightest apparent injury.* Mr. Horst was assured it was a common practice, and frequently adopted by village *punchayets* as an ordeal in trials for theft and murder. The work was continued during the two following seasons, the plane-tabling including part of the Western Satpuras and the valley of the Tapti. Great obstacles were encountered by the surveyors, partly from the high and rugged character of the hills, but chiefly from the difficulty in getting supplies and the general inhospitable nature of the country. The only water available for drinking was of the most unwholesome description, to which may be attributed the constant attacks of fever to which the assistants who surveyed the worst parts were subjected. The culminating portion of the Satpura range "Astamba," 4,346 feet above sea-level, came into the season's work. About 900 square miles on the two inch scale were surveyed between the town of Dhulia and the Tapti river, this tract consisting mainly of undulating revenue-paying districts. An attempt was made, on the whole successfully, to incorporate the village boundaries from the Bombay Revenue Survey maps. Captain W. J. Heaviside, who took charge of the party in 1879–80, furnishes some picturesque descriptions of the trap formation of the Deccan, which in Khandesh assumes the form of grand black precipices surmounted by massive basaltic columns rising to three or four thousand feet above sea-level. Two conspicuous basaltic hills, known as Mangya Tangya, on a spur of the Sahyadri hills, are of remarkable appearance, resembling monoliths rising from pyramidical bases, in which numerous steps have been cut. Some Buddhist temples, hewn out of the solid rock, are also to be seen here. The following season saw the detail survey carried forward in the south-western portion of the area allotted to the party, where it abuts on Berar and the Nizam's dominions. The inhabitants of this part mostly speak Mahrati, and are rather addicted to drink and theatricals, which latter entertainment affords a means of support to a class of strolling actors.

The Khandesh and Bombay Native States Survey was finally brought to a conclusion by Major T. T. Carter in 1882–83. It had

* *See* page 47 of Topographical Survey Report for 1876–77.

been started in 1871, and comprised an area of 18,133 square miles, including Khandesh and some of its outlying villages in the Nizam's territory. Of the total area about 10,532 square miles have been surveyed and published on the one-inch scale, and the remaining 7,601 square miles have been surveyed on the two-inch scale, but published on the one-inch scale. The first-named part comprises the rugged and hilly tracts lying between the Tapti and Narbada rivers, forming portion of the Satpura range and the tract of country lying above the Ghâts of the Satmala hills; that surveyed on the two-inch scale consists of the alluvial valleys of the Tapti river and its tributaries, where the country is richer and productive. In these parts the valleys are numerous, well cultivated, and connected by good roads, and the Great Indian Peninsula Railway traverses it from south-west to north-east.

The Bhopal and Malwa Survey party was originally organized in 1862 for the survey of Rewa and Bundelkhand, and on the completion of that work was transferred in 1871 to Bhopal and Malwa, to deal with all the country north of the Narbada river in the Central India and Rajputana Agencies between the parallels of 22° 15′ and 24°, and bounded on the east by Saugor and on the west by Mahi Kanta and Rewa Kantha. The survey lies intermediate between the operations of the Gwalior and Central India party to the north and the Khandesh and Bombay Native States party to the south. Up to 1877 the out-turn of topography in Bhopal and Malwa had been a little over 16,000 square miles. The work of 1876–77 saw the practical completion of the topography of the Vindhya range, which runs generally east and west through the area of the survey. Between the towns of Dhar and Amjhera there runs a low ridge extending northward some 30 miles, and the point where this ridge issues from the Vindhya range is the water-shed* of three of the river-systems of India, viz., 1st, the Narbada, which lies to the southward and flows westward into the Gulf of Cambay, 2nd, the Mahi, which rises to the north-west and discharges into the same gulf after a circuitous course, and, 3rd, the Chambal and Chamli rivers, which, rising to north-east, unite near Barnagar and join the Jumna. During 1877–78 fever prevailed in almost every camp, but a fair out-turn of work was nevertheless attained, while in the following season large scale surveys of Indore and

* The height of the water-shed is apparently 1,883 feet. *See* Captain Wilmer's Narrative, Surveyor-General's Report for 1878–79, page 13 of Appendix.

Dewas were completed in addition to the ordinary mapping. The greater part of the ground covered by the surveyors of this party proved tedious and intricate to the plane-tablers. Major J. R. Wilmer, who was in charge, mentions a peculiar custom that the Bhils have here of branding their male children on the arms above the wrist with burning cotton dipped in oil, so as to enable them to be identified as true Bhils. This custom appears to have been unknown to previous writers. At the close of the season 1881–82 it was arranged that the bulk of this party should be transferred to the Mirzapur district, while the few remaining sheets of the Malwa survey were entrusted to the Khandesh and Bombay Native States (No. 2) party, who had completed their work in the season 1882–83, and assumed in consequence the designation of the Bhopal and Malwa Survey party. The latter work was brought to a termination in 1884–85, the entire out-turn of the 15 seasons having amounted to 29,262 square miles, comprising 59 standard sheets, all surveyed on the one-inch scale. In addition, large scale surveys were made and mapped of 13 cities and cantonments, representing an area of 127 square miles. The survey had been commenced in 1870–71 by Major Riddell, R.E., and carried on by that officer till 1873–74, when the charge of the party devolved on Lieutenant-Colonel Wilmer, by whom the work was continued till 1882–83, when the party was transferred to Mirzapur. The late Khandesh (afterwards re-named the Malwa) party, under Major Carter, R.E., then resumed this work and did a full season's area in 1883–84, and in the following season the charge of the survey was entrusted to Mr. Patterson, by whom the work was brought to a completion. While working in the Udaipur State some sensational stories were circulated respecting the poles erected as signals to mark the trigonometrical stations, which the natives were convinced were intended for the immolation of the men and women. Another rumour circulated was that the survey party had come to weigh all the married men and women, and that of those found of unequal weight there would be a redistribution, thus disturbing their marriage ties. The Udaipur Durbar, in consequence of these rumours, desired the survey party to retire as soon as possible, but Mr. Patterson took the occasion to invite the Bhils to the camp and encouraged them to dance and sing and shoot at a target with their bows and arrows, afterwards dismissing them with *douceurs*. A description by Mr. G. P. Tate of the town of Bhinmal and surrounding country will be found

in the Appendix to the Report of the Surveyor-General for 1884–85, page xxx.

Central Provinces, &c.—Turning now to the operations which had been progressing in the east of the Peninsula, we find that the season 1876–77 was signalised by the completion of the Central Provinces and Vizagapatam Agency Survey, embracing altogether 72,144 square miles. The difficulty and unhealthiness of work in this region had been almost proverbial from its commencement, and its successful termination was a matter of genuine congratulation; the previous operations were mainly associated with the name of Colonel Saxton, who is frequently mentioned in the "Memoir": to Captain Holdich belonged the credit of completing the work, though this was not done without much cost and suffering to all the members of the party, some of whom were so prostrated by jungle fever that they were with difficulty removed from the field on the conclusion of the work. The characteristic features of the country where the concluding operations lay were extensive plateaux of from 1,800 to 2,000 feet above sea-level, surmounted by masses of flat-topped hills. These high lands are a continuation of the great plateau system of Central India, which decreasing in elevation by a succession of steppes finally breaks to the west into the low-lying plains forming the basin of the Godavari. The geological structure of this part of the country is mixed, being composed of trap and varieties of sandstone and slate; the first occurs in the higher flat masses, while the two latter predominate in the lower hills, and are distinctly separate one from another, a circumstance producing bold, rugged, and ever-changing scenery, but always the same endless monotony of forest from the plains to the highest peaks. The Pertabpur taluk on the right bank of the Kotri abounds in tigers, and sometimes whole villages are deserted through their depredations.

Another survey also brought to a conclusion in the same season was that of No. 4 party, N.E. Division, Central Provinces Survey, which had originally been organized by Colonel De Prée in 1856, and during the 22 years of its existence had triangulated and mapped on the one-inch scale a tract of country extending from the Bay of Bengal at Balasor to a point nine miles east of Jabalpur. This tract extends over nine degrees of longitude, and on an average two degrees of latitude, and its area amounts to nearly 25,000 square miles. The difficulties overcome here were of no

ordinary nature, for the country is a continuation of the Vindhya range, which crosses India from Bombay on the west towards Calcutta on the east and then turns southwards to Madras, forming everywhere the water-shed between the great river-system draining into the Bay of Bengal, and that towards the west into the Indian Ocean. The land is almost entirely a series of plateaux of one uniform height between 2,000 and 3,000 feet above sea-level, and of a wild, hilly, and inaccessible character, destitute of roads, and inhabited by an original population of Kols and Gonds, as well as minor tribes. In addition to the ordinary survey, 11 Government reserved forests were mapped on the four-inch scale. Alphabetical lists were compiled of each State, the areas computed, the houses counted, and the whole arranged in a compendious form as a gazetteer for each of the standard sheets. The Chota Nagpur Division of the Central Provinces covers 75 sheets, of 30′ longitude by 15′ of latitude, and the North-Eastern Division, 42 sheets.

Assam.—The desultory and detached nature of the frontier surveys and explorations on which the Khasia, Garo and Naga Hills party (No. 6) had been for some years engaged, necessitated its being broken in 1876–77 into three distinct sections or detachments. Major Badgley, the officer in charge of the party, undertook the revision of certain work in the vicinity of Shillong; Lieutenant R. G. Woodthorpe, R.E., and Mr. M. J. Ogle were detached to explore a wild part of the Lakhimpur district at the extreme head of the Assam valley, south-east of Sadiya, and close to the Burma frontier; while the other two assistants were deputed on the Khasi, Kamrup, and Garo Boundary Survey. Under these circumstances the cost of the work was necessarily higher than usual, while dense forest, swamps, want of good drinking water, venomous insects, and fever seriously impeded the progress of Lieutenant Woodthorpe and Mr. Ogle's work. Both these officers contributed some interesting descriptions of the country and of the manners and customs of the Singphos, Kamtis, Nagas, and other tribes met with.

The next season (1877–78) saw Major Badgley again engaged in the revision of the survey work between Gauhati and Shillong, (which had been done under unfavourable circumstances, necessitating a re-examination of the ground), and also in triangulation in Sylhet, where the swampy and malarious character of the place, and the

cowardly and malignant behaviour of the inhabitants, whom Major Badgley found to be a particularly obnoxious and untrustworthy lot, proved awkward obstacles to progress.

Lieutenant Woodthorpe was deputed with an assistant in the first instance to accompany Lieutenant Harman to the Miri hills, as already mentioned on page 52. On his return, Lieutenant Woodthorpe proceeded to Sadiya, and without waiting for his Mishmi carriers, who had failed to put in an appearance, he ascended a range of hills rising about 9,000 feet high, and overlooking the main valley of the Dibong, and succeeded in acquiring the following:—(1) a fairly accurate knowledge of the sources of the Dibong, and the course of its main stream in the hills; (2) an accurate knowledge of its course in the plains, and of about 1,000 square miles of the hills bordering it; and (3) an approximate knowledge of an additional 1,100 square miles in the hills. The Dikrang, Diphu, and Digaru rivers were also mapped.

This party had been engaged for several years in surveying the hills south of the Brahmaputra river, the greater portion on the half-inch scale, when in 1878 Major Badgley was instructed to undertake a full topographical survey on the larger scale of two inches to the mile of all the land on the south of the Sylhet district left unsurveyed by the Revenue Survey, and afterwards to make a detailed survey of the boundaries of tea grants and estates. The want of accurate surveys was believed to be costing Government heavily in fraudulent zemindari claims. With the assistance of some surveyors lent from the Revenue Survey Branch this work was taken in hand. Much difficulty was experienced in triangulating, the stations being in most cases platforms supported by bamboo scaffolding round trees, the tops of which were cut off and the levelled stump used as a stand for the theodolite. Great care had to be taken not to touch the tree, as once set swaying it took some time to come to rest, and the wind for the same reason sometimes put a stop to observations. Major Badgley says of the Tipperahs that they are active fellows, and excellent hands at jungle cutting, but their fondness for burning the forests makes them undesirable cultivators. The Manipuris he describes as pleasant-spoken, independent, and good hands at a bargain, but in matters concerning land as often victimised by the Sylhetias, who are strong, cowardly, morose, and quite uncompromising in their hatred of Europeans.

During 1879–80 and 1880–81 Major Badgley found it very difficult to get coolies, while work was further retarded by the difficult ground, consisting principally of hills, forest, and swamp. One of these swamps called Hakaluki Howhar is about 20 miles long by 9 miles broad during the rains. Major Badgley says that he had to cross it once during winter, and was up to his waist in water and weeds in it from eight o'clock in the morning till past 10 at night. In the following season the country under survey lay further to the west, about the lower spurs of the Tipperah hills, running northwards past the British boundary into the plains of South Sylhet, as well as the isolated groups of low hills lying between Fenchugunj and the Manu river. These tracts of country up to that time described on the maps as "hills covered with " impenetrable jungle" were rapidly becoming very valuable, as they were being taken up and opened out for tea cultivation. Lieutenant-Colonel Woodthorpe, who was in charge of the party, remarks on the beauty of South Sylhet. The following graphic description from his pen is worth quoting :—

"At four o'clock in the afternoon I am standing on a cleared hill just above a large tea garden. The air is beautifully soft and balmy, and looking to the east I see below me the gentle undulations and flat ground under tea cultivation, the rich dark green bushes standing out in bold contrast on the red-brown soil. Among the bushes the busy coolies are at work, the women adding brightness to the scene with their brilliantly coloured robes. In the midst of the cultivation on the banks of a clear stream, in a small, well-kept enclosure with a pretty tank, stands the manager's bungalow, a large commodious house, with white-washed walls and lofty thatched roof, slightly hidden by tall plaintain trees. Rose bushes and other shrubs flourish in the garden, in which from my elevated standpoint I can see that the useful is not overlooked in the culture of the beautiful, as testified by a corner where many tempting-looking vegetables are growing. With the orange glow of the afternoon sun upon it, the bungalow, with its garden, looks, as indeed I find it, a very haven of rest, comfort, and hospitality. I hear voices behind the bungalow near some large, neat tea-houses, and, looking, I see an excellent tennis court, where an exciting contest is being carried on between the young planters of this and a neighbouring garden. Beyond, the view due south is closed by the virgin forest of dark-trees and feathery bamboos, the greater portion of which will soon, by the enterprise of the planters and the extension of the tea gardens, disappear. To the south-west and west the eye wanders over the plains of South Sylhet, bounded on the south by the jungle-clad hills of Tipperah, purple now and indistinct. The flat green fields, above which, as the sun sinks, soft mist wreaths float, are broken up by frequent clumps of mighty bamboos or fine old banian trees, amid whose dark recesses a few glimpses of reddish roofs and the light blue smoke curling upwards denote the presence of villages. Beyond these to the west and north lie open expanses of what at this season is dry, or at the worst, only damp ground, but which a few of the March and April storms

will speedily convert into swamps, and even lakes. A thin dark line appearing here and there marks the course of a river, its waters now very low and hidden by the high banks, above which the masts of country boats and the smoke from the funnel of a steamer, just about to anchor for the night, are visible. Far away to the north beyond the plain, the trees, the villages, and the station of Sylhet itself, rises the long, level outline of the Khasia hills, faintly glowing in the sunset. A hum of voices ascends from the villages below, cows wend their way homewards through the deepening gloom, and as the sun sinks in the brown obscurity of the distant horizon, I shut up my theodolite, and running down the hillside, soon find myself at the bungalow, where a hearty welcome and an excellent dinner await me."

Colonel Woodthorpe takes occasion to record in his report the very great assistance and hospitality rendered to him and to his followers by the planters, who in several places are making good roads themselves, and so actively helping to open up the country.

Mr. A. W. Chennell, an energetic and valued member of this party, died in Bombay Harbour on the 5th October 1883. The disease to which he succumbed had originated in an accident he met with during the previous season while traversing a stream in the Tipperah hills. He had always been mentioned in the highest terms by the officers under whom he served during the 19 years he had been in the Department, and he was one of the surveyors who were specially selected for service in Afghanistan during the late war.

The season of 1883–84 was to have been occupied in the survey of the Noa Dihing valley and the hitherto unexplored portions of the Patkoi range on the extreme north-eastern frontier of Assam, but owing to the Aka raid on Balipur, the work was postponed, and the survey party, in accordance with the wishes of the Chief Commissioner of Assam, was ordered to accompany the military force which was sent into the hills to rescue British captives. The topographical results appear to have been meagre, as the military authorities did not permit Colonel Woodthorpe to visit much of the Aka country. He and Mr. Ogle subsequently explored some of the Daphla hills, discovering in the course of their work a branch of the Bhoroli named Kameng, of which large stream no one had ever heard. The weather was, however, exceptionally bad, and Colonel Woodthorpe considers that on the north bank of the Brahmaputra the higher ranges are seldom free from cloud and rain after November.

The season 1884–85 was devoted to work on the extreme north-eastern frontier of Assam, where a knowledge of the mountainous region between the head of the Assam valley and the upper waters

of the Irawadi is even now (1891) very important, as the establishment of a direct means of communication between the two countries will be a great administrative and commercial gain, and help towards opening up this part of Upper Burma. No. 6 survey party, consisting of Colonel Woodthorpe, Mr. Ogle, and Mr. Ewing, with an escort of the 44th Gurkha Light Infantry, and some Frontier Police under the command of Major C. R. Macgregor, explored this tract in 1884–85, ascending the Noa Dihing river from Sudiya, and crossed the Chankau pass (8,400 feet) over the dividing range. From an adjoining mountain, Mokoshat, the Brahmaputra and Irawadi rivers can both be descried on a clear day. The inhabitants of this part of the Upper Irawadi are Kamtis or Shans, and Buddhists by religion; Major Macgregor believes them to be of Siamese stock. The reception they gave the English was friendly, and they appeared to be particularly honest. The furthest points reached by the surveyors were Langdao and Padao (the capital) on the M'Li-kha river (one of the affluents of the Irawadi), a little south of Lieutenant Wilcox's furthest, after which the party returned and crossed the mountains at an altitude of 5,500 feet into the head waters of the Kyendwen, re-crossing eventually by the Patkoi pass (2,860 feet) into Assam.*

Part of the region to the south-west, intermediate between the Naga hills and the Hukong valley, was explored in 1888 by an expedition under Mr. J. F. Needham, Assistant Political Officer at Sadiya, Mr. Ogle being again attached thereto as surveyor. The starting point was Margherita, the terminus of the Assam Railway, which was left on the 4th January, and to which the expedition returned on the 28th February, having failed to reach their objective point in the Hukong valley owing to difficulties in obtaining carriage, the lateness of the season, and other causes, but having demonstrated the practicability of reaching the Hukong valley by two routes, viz., 1st, by the Nongyong lake, and 2nd, by the Naga hills route, which goes through the mountains south of Margherita. The pass over the Patkoi on the outward journey was found to be 4,147 feet, while that on the return was 7,192 feet above sea-level. About 1,500 square miles of entirely new country lying south of the Patkoi range (up to which the surveys of 1873–74 had been carried) was surveyed by Mr. Ogle, who has established a reputation

* *See also* Proceedings of the Royal Geographical Society for 1885, pp. 541 and 751.

by his successful work in these regions, and the new work was connected with that done further eastward in 1884–85. The Nagas met with south of the Patkoi have some cruel characteristics, and are addicted to human sacrifices; but they nevertheless were friendly disposed towards our troops, and gave useful assistance in various ways.

This piece of exploration was the last accomplished by No. 6 party, which was finally dissolved on the 16th July 1885. A retrospect of its history since its formation in 1863 is given by Mr. Ogle at page viii of the Appendix to the Report of the Surveyor-General for 1884-85.

The important survey of Sikkim which was carried out by Lieut. Harman after completion of his work in Northern Assam is described at pages 126 and 127, *infra*.

Rajputana and Simla.—This party (No. 7) was divided in two detachments in 1876–77, Lieutenant E. P. Leach, R.E., being engaged on an elaborately contoured survey of the Observatory hill, Simla, and Mr. R. Todd in prosecuting the detail survey in the desert portions of the Marwar (Jodhpur), Shekawati, and Bikanir States in Rajputana, as well as a large scale survey of the city and environs of Jodhpur and 50 linear miles of forest reserve boundaries in Ajmere and Merwara. On the return of the party to recess quarters the triangulation for the survey of the approaches to Simla and of the several military cantonments between Simla and the plains was taken in hand and carried over 120 miles.

Owing to the failure next year of the rains in Central and Southern India, it was not feasible to send more than a small portion of the Rajputana party to that province, so the remainder were employed in the neighbourhood of Simla, where a total area of 104 square miles of roads and adjacent strips of country was surveyed on the 6-inch scale, together with plans of Subathu and Kasauli cantonments. The system of topography employed by Colonel De Prée for the hills in these surveys was the same as employed by Lieutenant E. P. Leach in the previous season, *i.e.*, a combination of contour lines, sketched by eye, with other contour lines which had been accurately determined by water level, carefully followed in succession by the topographers and accurately delineated on the plane-table. Thus on the 6-inch maps the true

contour lines represent vertical intervals of 250 feet between which were drawn nine eye contours at about 25 feet apart, while in the cantonment maps on the 24-inch scale the true contour lines ran at vertical intervals of 50 feet between which there were four eye contours. This method of contouring proved valuable, enabling, as it did, native surveyors with no aptitude for hill sketching to produce accurate maps of difficult hill country, and reducing the delineation thereof to a comparatively mechanical operation.

Operations in 1878–79 were resumed in the Bikanir desert, where the ground was characterised by the regular sand waves formed by the prevalent south-west wind, and a general paucity of vegetation. The country, however, may be said to be culturable, for it only requires for the sand to be scratched up, seed to be sown, and the rainfall does the rest. It is said that when the rainfall has been good and the locusts do not destroy the standing crops one year's harvest will feed the people for three years. By December the crops are all off the ground, and after that, till the next rains, the Bikanir cultivators remain idle in their houses. The ground traversed during the following season was of the same rather uninteresting description, being varied only by the salt works at Sar and the sandstone quarries at Khari. In the former a coarse salt is produced by solar evaporation, and in the latter a stone of good colour and of compact texture, of which the stratum is horizontal and close to the surface.

During the following year, as the work moved gradually to the north and west, the country became even more desert-like than before; but in the Jodhpur State a welcome change ensued, the usual rolling sand hills and ridges of the desert being replaced by extensive plains composed of sandy clay, all more or less fertile, varied by clumps of rocky hills. The wells in this part of the country are of great depth, one measured by Mr. McGill, who was in charge of the party in 1881–82, being 480 feet deep, and the average depth being 270 feet.

At the close of the season the Rajputana party was transferred to Burma and merged into the Burma Topographical party, the Rajputana work being handed over to No. 1 topographical party, as mentioned above (*see* page 70).

Mysore.—The important survey of the Native State of Mysore* had been commenced in 1874–75, and good progress had been made during

* *See* Memoirs on the Indian Surveys, 2nd ed., p. 175.

the season. But in 1876–77 a serious famine overspread the greater part of Madras, and survey work in Mysore had consequently to be restricted to those tracts in the Nandidrug and Nagar divisions where it was easier to obtain water, provisions, and forage. This seriously lessened the out-turn of work of the two parties (Nos. 8 and 9), and at the close of the season, as so many members of these parties had been necessarily deputed to famine relief duties, it was deemed better to amalgamate the remaining survey officers into one party under Major H. R. Thuillier, R.E. (now Surveyor-General of India). On taking the field next year the prospects were better than could have been expected, considering the disasters to which the province had been subjected. The tanks were well filled, pasturage was abundant, and but for the deserted look of the villages a stranger could not have imagined that famine and drought had so lately been devastating the country. Nevertheless the season was particularly unhealthy. Fever of a virulent type broke out early in the field season in many parts, and all the European members of the party, except the officer in charge, were laid up, while the menial establishment, without a single exception, suffered more or less. During 1878–79 seven surveyors, assistants, and sub-surveyors rejoined the party after being temporarily employed on famine relief duties, so that it became practicable to split the party again into two detachments. One of these detachments was engaged in triangulating the western part of the State, preparatory to a detail survey of the tracts between Mysore and South Kanara, so as to aid in the settlement of the long-debated frontier survey, while the other detachment was occupied in the detail survey of part of the Nandidrug division. In the Malnad, as the country over which the triangulation extended is called, the principal feature is the Western Ghats, rising to a height of over 6,000 feet, covered for the most part with magnificent virgin forest, and forming the source of numerous rivers. The western face of this range is extremely precipitous, so as to be nearly inaccessible from that side, but from the eastern face numerous spurs branch out in all directions, and form more or less continuous chains of hills, which with innumerable undulations overspread the greater part of the State. The Malnad is essentially the country of rain and fog, and two or three months immediately after the monsoon season it is looked upon as most unhealthy for those not acclimatised to it. Its staple products are coffee, betel-nut, cardamoms, and pepper, and the trade is mainly effected by means of pack-cattle, locomotion being

difficult except along the roads, which are few and far between. Great efforts were made to complete the mapping of the Mysore-Kanara frontier during the following season (1879–80), but fever and sickness attacked the party, and at the close of the season two small gaps, aggregating about 25 miles in length, were unavoidably left. Owing to the difficulty of the country the ordinary method of working with the plane-table was in many cases utterly impracticable, and resort was had to special methods, particularly that known as plane-table traversing, in which the plane-table supplies the place of an angular instrument and the measurements are made by chain, a process slow at all times, but especially so when the chain lines, as in this case, had to be cleared through dense forest. The same procedure had to be adopted in 1880–81 in the survey of the western part of the province. The Assistant Superintendent, Captain J. R. McCullagh, R.E., accompanied the Boundary Commissioners in their work of demarcation, and inserted on the maps the position of the various marks erected by them. The general work of the party was much impeded by fever, from which all its members suffered more or less; one valued officer, Mr. R. Chew, Senior Surveyor, succumbed to a severe form of malarious fever contracted in the Bhadra valley. He had been 25 years in the Department, and had gained high commendation for his professional skill and steady attention to his duties.

A large out-turn of topographical work was rendered in 1881–82, this being due partly to the fact that so much triangulation had been accomplished in previous years that sufficient ground had been thereby prepared for the season's detail survey, and partly to the good health enjoyed by the party. As in former years, part of the work lay in the Malnad, where progress was necessarily slow, and part in the easier and more open Maidan country. The former part of the survey lay on the extreme western edge of the province, and included the famous Falls of Gersoppa, which are said to be the most picturesque falls in India. The Sheravati flowing over a very rocky bed about 250 yards wide here reaches a tremendous chasm 960 feet in depth, down which it is precipitated in four striking cascades. The Falls are graphically described in the "Mysore Gazetteer."*

During the seasons 1883–84 and 1884–85 the mapping of Mysore was steadily pushed forward under Major Thuillier. In the latter

* Volume II., pages 386–390.

year the country was exceptionally difficult, fully half of the area consisting of interminable forest and jungle, very sparsely populated even when villages existed at all. The most ordinary supplies (including water) were obtained only with great difficulty ; the heat was intense, severe and continuous physical exertion had to be maintained, the detachments were constantly molested by wild elephants and other beasts, and the unhealthy season prostrated several members of the party and a large number of the menial establishment. The entire survey was finally completed by Major McCullagh, R.E., in the middle of April 1886, and the whole of the records brought to a satisfactory termination by the 1st of October the same year. The area of the Mysore State proved to be 29,305 square miles, which was over 2,000 square miles in excess of the estimated area. A strip of the country was also surveyed outside and all round the state boundary. The Mysore Survey was based on portions of the three principal series of triangles known as the "Great Arc Meridional," the "Mangalore Meridional," and the "Madras Longitudinal." At the time of its commencement, in addition to the strictly topographical work on the scale of one inch to one mile, special surveys on a large scale of the various State forests within the province were contemplated, but after three of these forests, viz., Bilikal, Nandidrug, and Dwarayadurga had been completed, it was decided that no more should be undertaken. The mapping of the state is contained in 70 standard sheets, 4 sheets of Reserved Forest Surveys, and 19 sheets of Cantonments and City Surveys, chief among which were the surveys of Bangalore and Mysore towns. The survey was originally commenced in November 1875, and thus took 11 years to complete. The cost was entirely borne by the revenues of the State of Mysore.

On the conclusion of the Mysore Survey the party was transferred to the Madura and Tinnevelli districts of the Madras Presidency, it having been arranged between the Governments of India and Madras that the topographical work remaining to be done in the Presidency, aggregating about 12,400 square miles, should be surveyed on the 1-inch and the forests on the 4-inch scale by the professional Survey Department instead of by the Madras Revenue authorities. The adjoining Native States of Travancore and Cochin were also to be surveyed on the 1-inch scale, the old maps of the mountainous tracts of these States being very deficient.

The area plane-tabled during the season 1886-87 consisted of a block of hills from four to eight thousand feet in height, including the south-west corner of the Palnis and parts of Madura and Travancore. It is for the most part bare and exceedingly rugged, some of the precipices being tremendous, so that a body falling therefrom with a slight impetus would touch nothing for a quarter of a mile. The following season (1887–88) was exceptionally unhealthy, hardly a man escaped illness, and there were 12 deaths out of a comparatively small establishment. The operations of the triangulation included the *locale* of the Periyar project, an important and bold undertaking, which has greatly changed the character of the country, once the home of sambhar and of herds of wild elephants, but now swarming with troops of dusky coolies busied in excavating or raising embankments. The project consists in building a gigantic concrete dam, 160 feet high, across the Periyar river and cutting a tunnel 2,000 yards long, through which the imprisoned water will flow into the channel of a small stream that rushes down the face of the Ghât into thousands of thirsty acres in the Cumbum valley. The cost amounts to about 70 lakhs of rupees.*

During 1888–89 and 1889–90, the party were engaged exclusively on forest surveys in the Salem, Madura, and Tinnevelli districts, a class of work of increasing importance, which is already absorbing four parties in the Central Provinces, Bombay and Madras Presidencies, as well as a detachment in Orissa.

Kathiawar and Cutch.—The topographical survey of Kathiawar described at page 134 of the "Memoir" was brought to a conclusion by Major A. Pullan in 1879–80. It is an elaborate and important piece of work, surveyed on the 2-inch for reduction to the 1-inch scale, and consisting of 61 sheets. On its completion the operations of the party were extended into Cutch, and in 1880–81 the Great Rann or Runn was surveyed on the ½-inch scale. This remarkable tract, marked so conspicuously on the maps, consists of sandy waste and salt beds separating Cutch from the province of Sind. During the south-west monsoon the Rann is a shallow inland sea, but during the cold and beginning of the hot season a few roads cross it; at first oozy salt slime and water overlies it in patches, but as the

* The general appearance and character of the country are capitally and picturesquely described by Mr. R. W. Senior, p. iv. of "Survey Report for 1887–88."

warm weather approaches the hot winds blaze across the Rann like the blast of a furnace, clouds of dust render it impossible to advance, and travelling is safe only at night, the whole length of the road being marked out by the bones of the cattle and camels which have died from exhaustion *en route;* a heavy fall of rain closes the road for days, and camels caught therein have but little chance of escape. Before 1819 the river passing through the Rann was crowded with boats carrying the produce of Sind down to Lakpat, but in that year an earthquake closed the river and destroyed several villages.*

During the following seasons the Cutch survey was continued by Colonel Pullan. On one occasion while out surveying he was attacked by a panther and a good deal mauled about; these brutes, together with lions, haunt the Gir mountains of Kathiawar, and the former are said to be not unfrequent in Cutch. The survey was finally brought to a conclusion by Colonel Pullan in 1886.

Gujrat.—The Gujrat survey was organized for the purpose of dealing with a large strip of country extending along the western confines of the Bombay Presidency from the Rann of Cutch in the north to Nasik in the south. From the first Colonel Walker devoted his best efforts to utilize the mapping work of the Bombay Revenue surveyors who had already gone over all the cultivated tracts for settlement purposes. But the combination of the two surveys proved a difficult task; so during the rainy season in 1875 a conference was held at Poona with the view of settling (i) the scale on which the new Topographical Survey maps should be drawn, and (ii) the extent to which the older Bombay Revenue Survey maps could be incorporated and utilised. The Committee were also particularly asked to consider whether the 4-inch scale adopted by Major Haig in Gujrat, or the 2-inch scale adopted by Major Tanner and Captain Samuells in the Deccan and Nasik was preferable. Colonel W. C. Anderson was president, and the other members were Lieut.-Colonel Taverner, Lieut.-Colonel Macdonald, Major Tanner, Captain Samuells, Major Haig, Major-General Bell, and Colonel Merriman. The last two were engineers, all the others were Survey officers.

* Sir Bartle Frere wrote an interesting paper on the Rann of Cutch for the Royal Geographical Society. *See* R. G. S. Journal, xl., p. 181. Mr. W. T. Blanford also discussed the former existence of a sea covering the Rann, Journal Asiatic Soc., Beng., xlv., p. ii., 1876.

Unfortunately, the Conference did not agree upon a report; no reply was given to the first question put, and great differences of opinion were manifested in regard to the best scale to be adopted.

The Government of India, being thus *inops consilii*, fell in with the middle course suggested by the Bombay Government; they decided that the 2-inch scale should be prescribed for the Topographical surveys, and that the Bombay revenue sheets should be utilised wherever they could be used with advantage. At the same time, the Bombay officers were directed to supply in future such additional topographical details as might be required.*

The Topographical party in 1876–77 was under the care of Colonel C. T. Haig, who in March made over the charge to Lieutenant J. E. Gibbs, R.E. A good amount of topographical work was turned out, the greater portion being in the Native State of Baroda, which occupies a central position in the area allotted to the survey. Lieutenant Gibbs was, however, attacked with cholera on the resumption of the field work, and unfortunately died on the 21st November 1877. Though quite young he was one of the most promising officers of the Department, his abilities were of no mean order, and his descriptions of the Dangs† and other localities surveyed by him showed considerable power of observation. The native establishment of the survey also suffered a good deal in health from the effects of the famine. Lieutenant Gibbs was succeeded by Lieutenant St. G. C. Gore, who was transferred from the neighbouring Bhopal and Malwa survey, and who surveyed 68 square miles of the Dangs Forest tract on the 4-inch scale. The maps of British territory published on the 2-inch scale included, in addition to the details of the ordinary 1-inch scale maps, minor roads, and communications, and so many of the field boundary, triple junctions, and other points on the village maps drawn up by the Bombay Revenue Survey that would facilitate the further incorporation of all the details of those maps, if required for the purposes of any new road, canal, or other engineering work. For this work the Bombay Government supplied a special auxiliary agency, consisting of an assistant superintendent from the Bombay Revenue Survey and a native establishment, at a cost of Rs. 500 per mensem. The same Government also contributed Rs. 30,000 towards the extra cost of

* Letters from A. O. Hume, C.B., Secretary to the Government of India, Nos. 134 and 136, dated 9th February 1876.

† In the Appendices to the G. T. S. Reports for 1873–74 and 1874–75, pp. 32A and 36A, respectively.

the Dangs survey, this being divided into four annual instalments, and the Baroda Government contributed Rs. 5,500 per annum towards the expenses of surveying their State, on the condition of 550 square miles per annum being surveyed until completion of the whole. In April 1881 Colonel Haig, who had had charge of the party for some years, was deputed to the Geographical Congress at Venice,* and the command devolved first on Captain Hobday and then on Lieutenant-Colonel Leach, V.C., R.E. The survey in the Dangs Forest, which in previous years had been found to be attended with much malarious fever, had by this time reached a more open country, and it was thought the field work might be safely commenced early in the season; unfortunately the ground is then covered with high dense grass, and all the surveyors, European and native, with a single exception fell ill, thus the experiment failed and the season's out-turn of work fell below what had been expected. During the same year (1880-81) Mr. Le Mesurier and the native establishment of the Bombay Revenue and Settlement Department were re-transferred to their own department after having been attached to the Gujrat Survey for eight years, during which time they had done good service in map-drawing and incorporating the details from the Bombay Revenue Survey maps into those of the professional survey party. In 1881–82 the plane-table work included the northern part of the Baroda State which is watered by the Saraswati river, and to which much historic interest attaches. Patan, one of the chief towns in that locality, is built on part of the site of Anhilwada, the old capital of Gujrat before Ahmadabad was built. Anhilwada is said to have been 18 miles in circumference, and the heaps of old ruins to be found for miles round Patan seem to corroborate the statement. Patan and Sidhpur are both situated on the Saraswati river, which is venerated as a goddess, and the latter town (Sidhpur) is a noted place of pilgrimage, the remains of the Rudra Mala Temple of Shiva being an object of considerable archæological interest. Another remarkable feature of the season's survey was the hot sulphur spring of Unai on the boundary between the Baroda and Bansda States, into which at certain seasons crowds of people rush and bathe without cessation for two or three days together. The water as tested by Colonel Haig was of the temperature of 138° Fahrenheit, but this is probably

* Two medals were awarded at this Congress to meritorious Indian native explorers, one being assigned to M—— S—— (*see* page 142) and the other to A—— K—— (p. 156).

lowered by the continuous stream of human bathers, who are further encouraged and fortified by doses of intoxicating *bhang*.

The survey of the Dangs forests was completed in 1882–83, and a survey of the Panch Mahals, incorporating the fiscal details of the Revenue Survey village maps and including forest boundaries, on the 4-inch scale was commenced in the same year. Colonel Haig caused a special survey to be made (so far as the scale permitted) of the hill of Pawagarh, which with the remains of the old city of Champaner at its base, forms an object of considerable historical and archæological interest, and of which no previous map existed. It abounds with old Jain temples, more recent Muhammadan fortifications, mosques, buildings, and tanks, and still more recent Hindu temples. Colonel Badgley took charge of the survey in 1884–85, and the work during that season consisted practically of nothing but 2-inch scale work. Late rains increased the natural unhealthiness of the country, so that nearly one-fifth of the working season was lost through sickness. The detail survey of Baroda city was finished in 1885–86, and an exceptionally large area of topography was covered during the same season, much of the ground consisting of open plain. The operations were in charge of Mr. J. Newland during the greater part of the time, owing to the paucity of available officers of the senior division. In the next season the party was divided into two sections, one proceeding to Surat and Palanpur to carry on the topographical survey of Gujrat on the 2-inch scale, and the second to Kalyan taluka to commence surveys on the 8-inch scale of the Forest Reserves in the Thana district which had been requested by the Bombay Government. The surveyors employed on this work suffered much from fever, which is specially prevalent in those tracts between November and January (both months inclusive). In 1887–88 the 2-inch scale work lay within two of the northernmost sheets of the area of the survey close to the limit of the Gwalior and Central India Survey, one of which sheets includes the cave temple of Menaknath, which lies embedded in the side of a hill seven miles south-east of Danta. It is said to be capable of accommodating 2,000 persons, and is a sacred place of pilgrimage for Hindus. A large scale survey of Disa cantonment and environs was also completed.

In consequence of the Bombay Government having proposed the organization of a special Forest Survey Branch for the future conduct of forest surveys in that presidency, a conference was held at Poona

in July 1888, at which the Secretary to the Government of India in the Revenue and Agricultural Department, the Surveyor-General, and the Deputy Surveyor-General attended and discussed the matter. A general scheme was arranged, the following being the principal points:—

(1.) One party of the topographical survey of India to be placed fully equipped and manned at the disposal of the Bombay Government for the purposes of forest surveys in that presidency, to be utilised in such manner as that Government may think fit.

(2.) The cost of the party to be debited to forests, by which half the cost will be borne by imperial and half by provincial revenues.

(3.) The normal scale for the Forest Survey maps to be four inches to the mile instead of eight inches.

(4.) The officer in charge of the party to be under the control and supervision of the Survey and Settlement Commissioners, supervision over his work being also maintained by the Surveyor-General of India.

These conditions having been accepted by the Government of India, the Gujrat party with slight modifications as to *personnel* (the topographical section having been withdrawn and the forest section from No. 10 party added) was placed at the disposal of the Bombay authorities, and the programme for 1888–89 arranged by that Government. The work of the northern circle lay principally on the ridges and spurs of the Ghats, on the low hills of the Konkans, and on the plateaux of the Northern Ghats, while the forests of the southern circle, from the dense nature of the undergrowth, were most tedious and unhealthy to map out.

The area remaining for topographical survey in Gujrat, Rajputana, and the Southern Maratha country was entrusted to the old party, which also worked in two sections under Colonel Hutchinson. Part of the frontier of the Nizam's dominions was mapped, during which an assault was made on the surveyors by some villagers, who mistook them for excise officials. The ringleaders were sentenced to two years' imprisonment and a fine of Rs. 1,000 each. The survey and settlement of a large tract of disputed country between Mewar and Marwar were also undertaken.

Kohat.—On the withdrawal of the British forces from Northern Afghanistan in 1880 it was arranged that some of the survey officers

who had returned to India should be employed in making a standard topographical survey of the Kohat district, to supersede the preliminary reconnaissance survey which had been made in 1849-51 immediately after the annexation of the Punjab, and to complete the gaps remaining to be filled in on the frontier line up to the recent surveys in the Kuram valley and other contiguous portions of Afghanistan. The time was limited, but some useful work was done. Mr. McNair was deputed early in the season 1880-81 to effect a more satisfactory junction than had been possible during the progress of the military operations between Major Woodthorpe's triangulation in the Kuram valley and the old Kohat secondary triangles, fixed thirty years ago. He also undertook the topography of the Miranzai valley, through which the highway from Kohat to Kabul, by way of the Kuram valley, passes, and of which a good map was much required by the local officials. Major Holdich joined the party about the middle of February, but soon after his services were needed with the force under Brigadier-General Gordon, C.B., which proceeded from Bannu to operate against the Mahsud Waziris. An area of 2,000 square miles was covered by the Kohat triangulation, and 398 square miles were topographically surveyed on the 1-inch scale in the Miranzai valley, besides rough reconnaissances in the Urakzai, Tirah, and Bam valleys. A native explorer made a reconnaissance of the Zhob valley, and afterwards did good service with the Waziri expedition.

During the recess the party were engaged in making a standard topographical survey of the Kohat district on the 1-inch scale, and also on the final mapping of the surveys in Northern Afghanistan. The Kohat field work was continued by Major Holdich and Mr. McNair in 1881-82. The latter officer also succeeded in making friends with one of the Waziri chiefs, and was taken under tribal protection to make a reconnaissance of the tract of independent territory lying east of the Kuram river and immediately north of Bannu, which is inhabited by the Daresh Khel Waziris, and embraces the well-known range of hills culminating in the Kafir Kot, which Mr. McNair is the first European to have visited. The general aspect of the country is wild, and there is very little cultivation. In winter and spring as many as 6,000 fighting men are estimated to occupy the hills, but during the hot months scarcely 500 remain behind. The reputation of these gentry as highwaymen is great, and they are a source of considerable anxiety to the Deputy

Commissioners of Kohat and Bannu; they are, however, men of splendid physique, inured to all weathers and of great endurance, and it is a great pity that they do not accept employment under our Government.

Mr. Claudius surveyed a small area of ground, including Kohat itself, and the hill sanitarium of Mirkhwaili. He states that the whole of Tirah is well supplied with Sniders, and a number of men carry good Martini rifles. They boast that these weapons are plunder, secured during the recent campaigns in the Khaibar and Kuram routes. For the Sniders they have such an abundance of ammunition that cartridges are actually bought from Tirah by our men cheaper than in India. The manufacture of cartridges for the Martinis is even said to have been commenced by them with success.

The survey was finally brought to a conclusion in 1882–83, and a large scale plan of Kohat city and cantonment was completed the same year. The efforts made to reconnoitre the adjacent frontier under the protection of the tribes proved very successful, and thanks in great measure to the interest taken in the work by Major Holdich, the results were to supply reliable maps of the whole strip of territory extending from the Kabul river on the north to the Gumal on the south, the only exception being a small tract of country near the Gumal pass. With the assistance of No. 5 Topographical and No. 3 Revenue parties, Major Holdich was enabled during the recess to complete for publication the whole nine standard sheets of the survey of the Kohat district. The work being completed, the party was broken up, and Major Holdich with most of his assistants were transferred to the Baluchistan Survey.

Baluchistan.—In September 1879 Major R. Beavan was directed to proceed from Kandahar to Quetta to survey the country between and around Quetta and Sibi. On arrival at Quetta, finding that an expedition was about to start to explore the route to Sibi, viâ the Hanna or Hamra pass, he accompanied them, arriving at Sibi on the 12th January 1880, just in time to see the opening of this part of the railway and the arrival of the first railway train. He subsequently visited Khost in the Dargi valley, and then Tal, from which place he subsequently accompanied military expeditions towards Chotiali and to Baghao and Smalan on the north-east. Major Beavan's reconnaissance on the $\frac{1}{4}$-inch scale covered about 2,500 square miles, and extended from Quetta to Tal, Chotiali, and

down to Sibi. It proved of great use afterwards to the engineers employed in laying out the new line of railway. Some valuable survey work around Sibi, Mitri, and Dadur, was done by Messrs. Coxen and Corkery, assistant surveyors, who showed great tact in dealing with the Pathan and Baluchi inhabitants of the country. The obstacles in the way of survey work in Baluchistan were altogether exceptionally great. The local means of carriage were monopolised for the service of the troops, and the camel owners realised such enormous profits by carrying Government stores at so much a maund that they refused to take service by the month. Dust storms and haze were very persistent at times and prevented any satisfactory observations from being taken, water was often terribly scarce or almost unfit to drink, and as a natural result of bad water and an unequable climate, sickness was rife among both Europeans and natives. Another great drawback in Baluchistan is the extremes of temperature experienced. From March to November the low country is intensely hot, and from November to March the highlands between Quetta and Khelat are intensely cold, while during June, July, and August thick haze prevails.

By an order of the 12th July 1880 the party under Major Beavan's orders was organized as a regular party for the survey of Southern Afghanistan, Baluchistan, and the adjacent country under the designation of the "Baluchistan Topographical party."

During October, November, and December 1880 Major Beavan accompanied the expedition into the Marri country, but the unsettled state of the country rendered it impossible to leave the line of march in order to ascend any commanding heights. A survey of the actual line of route with bearings and paces was taken by Captain W. Gill, R.E.

The work of Major Beavan's party was described by him as a geographical reconnaissance on the $\frac{1}{4}$-inch scale of Sewestan and the Marri hills, and a more elaborate survey on the $\frac{1}{2}$-inch scale of the territories subject to the Khan of Khelat. In a geographical point of view Major Beavan applies the name Sewestan to the district drained by the Nari river and its affluents, one of rugged broken ranges of hills running mostly east and west. Huge cracks or crevices have been formed across the line of hills, and through these the drainage of the country makes its way, presenting the anomalous condition of parallel valleys with rivers running at right angles to them. In many parts the sandstone rocks lie broken and

mixed up in magnificent confusion, lending an appearance of truth to the old legend that after the creation of the world the spare rubbish was shot down here. Major Beavan says it is impossible to give on the map an adequate idea of such a country.

During the winter of 1881–82 the survey of the country lying between Quetta and Khelat was continued, the season's work comprising more especially that part adjacent to the Bolan and Rodbar passes. Major Beavan himself accompanied a military expedition under Brigadier-General H. C. Wilkinson to open out the routes between Tal-Chotiali and Dera Ghazi Khan. In addition to making a plane-table reconnaissance of the previously unsurveyed portions of the route which lay viâ Mandai, Tal, and Chamalang, Major Beavan took observations for the purpose of completing the Sewestan triangulation, and subsequently, accompanied by Mr. Corkery, and under the protection of an escort of Marris, made some useful additions to the survey of that country.

In the following season the work mainly consisted of triangulation, originating from stations of the Great Indus Series and carried over the Suliman range, the Khetran country, and a portion of the Marri hills, and closing on to the triangulation previously executed. A series of triangles was also commenced over the hill country between Khelat and the Kach Gandava plain. The season's topography was carried on in the hilly country east of Khelat during the autumn and again in the spring months, and during the cold months in the low country at the foot of the hills and also in the lower hills north of Sibi. In all an area of 1,844 square miles was finally mapped. A rapid reconnaissance was carried out by Mr. Coxen from Khelat to Nushki with a view to selecting stations for an extension of the triangulation in that direction, and also fixing the position of Nushki, which had been till then doubtful. In 1883–84 the party was divided into three sections, the one under Major Holdich, R.E., was employed on the Takht-i-Suliman expedition (see page 147), the second under Lieutenant Talbot, R.E., accompanied Sir Robert Sandeman's mission in South-west Baluchistan, whilst the third, under Mr. Claudius, took up the regular detail survey, and was further strengthened, after the Takht-i-Suliman expedition, by the arrival of Mr. Coxen and Sub-Surveyor Hira Sing. There was a large out-turn of triangulation, as well as a very creditable amount of topography on the ½-inch scale in the Tal-Chotiali territory and the Kachi desert.

Sir R. Sandeman's political mission to the distant town of Kharan in the Baluchistan desert in November 1883 afforded an opportunity for fixing the position of an outlying point of some importance in its relation to the Indian western frontier. The mission started from Khelat in November 1883. Lieutenant Talbot, who, with Lieutenant Wahab, was attached as surveyor to the party, carried his triangulation first southerly and then south-westerly, while Lieutenant Wahab worked at first westerly and then in a southerly direction. They met again at Garok, one march eastward of Kharan. Beyond the latter place Lieutenant Talbot extended the triangulation to Washuk, but from thence to Panjgur* the haze made it difficult to see objects five miles off, and a gap of 130 miles occurred in the triangles. Through the plane-tabling, however, a satisfactory junction was effected.

The requirements of the Afghan Boundary Commission, which was being organized at that time and to which Major Holdich and Lieutenant Talbot were attached, occasioned a considerable reduction in the personnel of the Baluchistan party in 1884–85, in addition to which Lieutenant Wahab, Mr. Scott, and Yusuf Sharif, who had been attached to the Zhob Valley expedition, did not return till the 17th December 1884. Mr. Claudius laid out a series of triangles 45 miles in length closing on stations of the Baluchistan Survey east of Khelat, and Yusuf Sharif established a connexion with the Zhob expedition triangulation and the G.T.S. points fixed from the Great Indus Series on the Suliman range. The out-turn of topography included an important bit of hitherto unexplored country stretching from the lower part of the Harnai valley northwards, and the survey proved of great value in determining the best route for the railway through this difficult country. Portions of the Bugti country, the Derajat frontier, the Kachi plain around Gandava, and the hilly country to the west were also surveyed in detail. Generally speaking, the operations of the party were extended over a very wide area of country, from the Suliman range on the east to the Khelat hills on the west, consisting for the most part of barren rocky hills and equally barren valleys sparsely populated by Baluch and Pathan tribes. Most of the ground west of

* There is a good deal of information about Panjgur and the Khan of Kharan in the late Sir Charles Macgregor's "Wanderings in Balochistan" (Allen & Co.), 1882. Panjgur was also visited by Sir Robert Sandeman in 1890–91, in his exploration of the old *kafila* route between Lus Beyla and Southern Persia.

the passes is tolerably elevated, and the surveyors' camps were often over 5,000 feet, but on the whole the country was easy to survey. The Kachi plain was the only tract differing essentially from this description, and that corresponds more in climate and general conditions to the adjacent Sind plain.

The party sustained a loss in the death of Mr. G. R. Copping, a young surveyor of great promise, who had served six years with the party. He was suddenly taken ill, apparently with fever, in one of the most desolate spots on the frontier, and was carried by his khalassies into Sibi to die.

An interesting description of the Marri country, with its three settlements, Kahan, Mamand, and Kolu, as well as of the Kachi and Harnai valley, was supplied by Captain Wahab, and will be found in the Appendix to the Report of the Surveyor General for 1884–85.*

During the next season the command devolved on Colonel Wilmer and the operations consisted almost entirely of special surveys for military purposes, viz.:—(i.) A survey on the 2-inch scale of the Khwaja-Amran range, towards Kandahar; (ii.) A survey on the 2-inch scale of the country surrounding Quetta; (iii.) An exploration of the routes between Registan and the Baluchistan frontier.

The triangulation in advance of the detail operations of the season was carried by Mr. Claudius southwards from Gulistan and generally along the meridian of 66° over Southern Pishin, the fertile valley of Shorawak, and the Shorarud hills. This triangulation connected the Kandahar, Khelat, and south-west Baluchistan Series, and furnished good bases for further extension westwards. Mr. Claudius wrote an interesting description of the country traversed, which has been printed separately.

The explorations under (iii.) were carried out by Sub-Surveyors Ahmed Ali and Sheikh Mohidin. The former started from Nushki, succeeded in making a reconnaissance survey with the plane-table of nearly 20,000 square miles, mostly on the $\frac{1}{4}$-inch scale. His exploration extended up to the Persian frontier, embracing country well to the north and south of the route followed by the Boundary Commission in 1884, including 360 miles of the course of the Helmund river, with its numerous villages on both banks. The country explored by Sheikh Mohidin was the portion of Registan immediately west of the Khwaja-Amran range. His plane-tabling covered an

* p. xxii.

area of about 10,000 square miles on the ⅛-inch scale, chiefly desert, through which all the important routes were laid down.

The general survey was continued by Captain F. B. Long, R.E., and Mr. Claudius in 1886–87, the country triangulated comprising parts of the districts of Khurasan and Jalawan between Khelat and the Sind frontier, while the topographical work lay in portions of the Bugti and Marri hills, the Khetrani hills, the Kachi near Sibi, the Bori valley, and the Luni Pathan country in the north, and the juniper forests about Ziarat. The Bugti, Marri, and Khetrani hills are extremely intricate, and great difficulties were experienced in procuring water and supplies, while the heat in April and May is described as almost unbearable. To the north the country is much less complicated, the valleys are wider and comparatively well inhabited, and the hill ranges running approximately east and west are well marked and easily delineated.

The same season saw the transfer of the Rajputana and Central India party to Baluchistan (see p. 70 *supra*), and Captain Wahab, R.E., who had been temporarily attached to the Himalaya party during the absence of Colonel Tanner with the Tibet mission, was placed in charge a short time prior to the party taking the field. The work included a detail survey on the 6-inch scale of about 27 square miles of country in the neighbourhood of Quetta, a 2-inch survey of the eastern portion of the Pishin plain and the Surkhab, Gwal, and Kach valleys, and the extension southwards of the 2-inch survey of the Khwaja-Amran range. The Baluchistan Survey had by this time (1887) unavoidably assumed such large proportions as to demand a rigorous trigonometrical basis, and it was therefore decided to carry two chains of triangles emanating from the Great Indus Series, one along the parallel of 30° N. latitude, and the other approximately to the meridian of 67° E. longitude, both to meet at Quetta. The latter part of the work was entrusted to Mr. Claudius, who successfully carried it out in a series of quadrilaterals comprising 19 stations, and spanning a direct distance of about 150 miles. The minor triangulation preliminary to detail survey on the ½-inch scale was extended over sheet 23 N.W., which lies east of Kuhak and south of Kharan.

The severity of the winter and the difficulties in the matter of carriage and supplies were found particularly trying both to the surveyors employed on the triangulation and to those engaged in detail surveying, but nevertheless over 7,500 square miles of topography were surveyed on the ½-inch scale. For the ensuing season

it was decided that only one party should be employed in Baluchistan, and that operations should be confined to the extension of the 2-inch survey in the neighbourhood of Quetta and Pishin, and in revising the survey of the country about the Bolan and Harnai routes.

The field work of the other Baluchistan party (No. 16) included the extension of the general survey of Baluchistan on the scale of half an inch to the mile, and a survey of the town and cantonment of Quetta on the 16-inch scale, with a record of all properties on the cadastral system. Minor triangulation preparatory to further extension of the ½-inch survey was carried on towards Kharan, and of the 2-inch survey south-west of Quetta. A series of secondary triangles was also extended by Mr. McNair from the Great Indus Series, near Dehra Ghazi Khan, along the parallel of 30° latitude up to Quetta, where it will join the Kalat Series. He carried out his work under trying circumstances with great care and accuracy. The exposure which this energetic and enterprising officer endured tried his constitution severely, and he unfortunately fell a victim to typhoid fever, and died at Mussoorie in the summer of 1889. Mr. McNair had joined the Department in 1867, and had served for 12 years in Rajputana and Mysore. From the first he displayed special aptitude for survey work, and during the Afghan War he had mapped out a good deal of new country, including the Lughman valley and other parts of the Upper Kabul valley. At the close of the war he was employed in the risky work of mapping the frontier line from Kohat to Bannu. But his most conspicuous achievement was his adventurous journey into Kafiristan, which gained for him the Murchison Grant of the Royal Geographical Society.* He was an able observer; he had readiness of resource, and a marked aptitude for gaining personal influence over the frontier tribesmen with whom he came in contact.

The country topographically surveyed by the party on the ½-inch scale in 1887–88 lies south and south-west of Khelat, and includes the highest part of the Brahui mountain system, which forms the water-parting between the Indus basin and the rivers that flow to the west. A large scale map of Quetta was completed during the recess. During January 1888, Captain Wahab and a sub-surveyor were told off to accompany an expedition under the Deputy Commissioner of Dera Ismail Khan for exploration in the Gumal pass. Unfortunately little or no additional geography was obtained, as Captain Wahab was unable to ascend any commanding hill beyond Kajuri Kach (up

* *See* page 149.

to which point the pass had been surveyed in 1883-84 by Surveyor Yusuf Sharif), but he obtained the heights of a number of points along the pass and of several hill peaks, which will be useful in future operations.

In October 1888 an important reduction was made by Government in the number of topographical parties, which were thereby brought down to three in lieu of six. This involved the breaking up of No. 16 party employed in Baluchistan, and a corresponding reduction in the amount of work turned out by No. 15 party, on whom the entire duty of mapping out this important agency thus devolved. Colonel Holdich took charge, and the equipment and stock were brought from Mussourie to Quetta, which thus became the headquarters of the Baluchistan Survey. In addition to the regular work, Sub-Surveyor Ahmed Ali made an important and plucky reconnaissance in Western Baluchistan, adding 19,000 square miles of geographical information to our maps, and practically completing all that remained to be done in that direction. Lieutenant Mackenzie, R.E., and Sub-Surveyor Imam Sharif, K.B., accompanied Sir H. Prendergast during his tour in Zhob and Eastern Toba in July 1889, and surveyed about 1,100 square miles, and Assistant Surveyor Yusuf Sharif, K.B., mapped a very large area of unknown country in Persia for the Intelligence Branch of the Quartermaster General's Department. On all three of these pieces of exploration separate reports were submitted. In 1889–90, besides the regular topography of Baluchistan, an area of 4,500 square miles was surveyed by Colonel Holdich and Lieutenant Mackenzie while attached to Sir R. Sandeman's expedition to the Zhob valley, and surveys were effected in Western Makran and the Perso-Baluch frontier.

Himalayas.—Since 1885 the party formerly employed in the Darjeeling Survey, under Colonel Tanner, has been deputed to take up the topography of the Hill States about Simla, and of the Kangra district, on the 4-inch and 2-inch scales. The very high mountainous regions, of which a fair proportion falls within the area of operations, are dealt with on the 1-inch scale. A few soldiers were attached to the party, to be trained in surveying, and Colonel Tanner reported that the experiment answered well, four men having acquired sufficient training in 1886 and 1887 to make, under supervision, a fairly accurate map of any country they might be called upon to survey.

V.

REVENUE SURVEYS.

The Revenue Surveys of India form the principal basis on which the whole fiscal administration of the country rests. In India the Government is the chief landowner, hence the determination of the area of the fields of the cultivators or of the zemindars,* with whom, as the case may be, the Government "settlement" is made, is a matter of prime necessity to the State. The ideal survey, as truly remarked in the "Memoir on the Indian Surveys," while furnishing complete information for settlement purposes, should be executed throughout on accurate principles and supply at the same time materials for compiling trustworthy maps for general use. A good revenue survey should also supply such agricultural statistics as will give a statesman knowledge to enable him to improve the condition of the people, to increase their means of subsistence, to avert famines, to add to the wealth of the country, and adjust taxation.

Although revenue surveys have been conducted on different principles in various provinces of India, the introduction and spread during the last 18 years of the cadastral† system indicates that the advantages of the best and most accurate principles of surveying, as understood by the chief Continental nations, are recognised more and more in India. The chapters in the "Memoir" have dealt with the development of the older system and the inauguration of the cadastral method up to the period just preceding the amalgamation of the three branches of the Indian Survey.

In 1876-77 the Revenue Surveys were conducted under the general supervision of General D. C. Vanrenen, Superintendent, by 14 parties, which were thus distributed, viz., two in the Punjab,

* Landowners.

† More than one derivation has been assigned to the word cadastral. The "Dictionnaire des Dictionnaires" derives it from the mediæval Latin word *capitastrum*, but the "Recueil des Lois et Instructions sur les contributions directes" defines it as a plan (probably from *cadrer*, to square) from which the area of land may be computed, and from which its revenue may be valued.

three in the North-West Provinces, six in Bengal, two in Bombay, and one in Assam. Of these 11 were regular survey divisions, and three smaller parties employed on special work distinct from the regular divisions. The total area surveyed and completed in detail was 12,544 square miles, of which 5,424 square miles were *muzawar* or village by village survey, at a cost of about 50 Rs. per square mile. The cadastral operations introduced into the North-West Provinces in 1871–72 had entailed very considerable labour in the publication of the maps, so it was arranged that about 5,000 of the sheets should be lithographed at Allahabad under the orders of the Board of Revenue, while an equal number were dealt with at the Surveyor-General's Photographic Branch. The Soane Irrigation maps, which were on a still larger scale, were most of them handed to a Calcutta firm for reproduction.

About this juncture an important question arose as to the success of the Survey Department operations in the Lower Provinces of Bengal, and the Board of Revenue expressed their opinion that the surveys necessary for settlement purposes might be done at far less cost by non-professional agency. This opinion led to the preparation of an elaborate statement by General J. T. Walker, the following extracts from which will give a good general idea of the three classes of operations:—

1. *The Topographical Survey, on the* 1-*inch scale.*

"This survey is constructed by the method of plane-tabling, on a trigonometrical basis, in such a manner as to exhibit the positions of towns and villages, the courses of rivers, the general features of the ground, and as much detail as the scale will admit of, with a sufficient degree of accuracy for the requirements of a general topographical map on the 1-inch scale. The surveyor goes over the ground with his plane-table, which he sets up at a sufficient number of points to enable him to 'cut in' all the most prominent objects and to sketch the general features of the country; the number of these points, called 'plane-table stations,' will vary with the nature of the ground, being few where it is flat and open and numerous when it is hilly and rugged. In all cases the plane-tabler actually goes over only a comparatively small portion of the ground, the greater part being sketched in from his stations. He surveys no village boundaries, but only the principal boundaries, viz., those of the British districts and the Native States and their sub-divisions when they have been demarcated beforehand."

The plane-tabling executed during the 10 years 1867–68 to 1876–77 was performed at the average speed of 55·8 square miles per mensem for each surveyor employed on that class of work, and the total cost of the surveys during the same period, including

triangulation, calculation, mapping, and supervision, averaged Rs. 21–12 per square mile. The agency employed was mixed European and Native, the former element slightly predominating and taking the greater share of the plane-tabling in hill districts and difficult ground and the lesser share in the plains.

2. *The Village or Muzawar Survey, on the 4-inch scale.*

"This survey is also constructed by the method of plane-tabling, but on a basis formed by carrying traverses (with theodolites and chains) round the boundaries of villages, instead of on a triangulated basis. The usual details of the ground are laid down by the plane-tabler, who is also required to delineate the limits of the land which happen to be respectively cultivated, fallow or waste at the time of survey. For this reason and because of the larger scales of survey, the plane-tabler has to go over the ground very much more closely than in the Topographical Survey, and his rate of progress is proportionally slower."

The total cost of the survey during the 10 years above mentioned averaged Rs. 53 per square mile. As a rule the whole of the plane-tabling was done by the natives, the Europeans (who were in the proportion of one European surveyor to about four natives) being employed on the traverses and calculations and in supervising and checking the natives.

3. *The Cadastral Survey, on the 16-inch scale.*

This survey is described at pages 182 and 183 of the "Memoir on the Indian Surveys." It is constructed on the basis of the traversed boundaries of the villages, but the whole of the interior details of the fields are obtained not by plane-tabling, as in the previous instances, but by systematic chaining, which is duly recorded in field books, and is thus available for future reference whenever it may be wanted. The agency consisted of about one European surveyor to four Native surveyors, in addition to 17 measuring amins. The Europeans were wholly employed on the traverses and calculations and in supervising the natives and testing their work by running check lines over it. The rate of progress was very variable, depending mainly on the average size of the fields, which in certain districts was one acre and in others two acres.

The work was comparatively new to the Department, having been commenced in 1871–72. Thus, in 1878, only six years' figures were available for purposes of comparison, and as during the first part of the time the surveyors were learning their work, the rates, which gave a general average of Rs. 165 per square mile, were

scarcely a fair criterion. It may be observed, however, that even these rates are almost identical with the average rate of the cadastral surveys under the Madras Government which averaged Rs. 162 during the nine years 1864 to 1872.

The relative intrinsic value of the three classes of survey.

Comparing the foregoing processes, it is seen that the rates in 1878 were Rs. 22 for the topographical 1-inch, Rs. 53 for the village or mouzawar 4-inch, and Rs. 165 for the cadastral 16-inch survey. For a cheap and fairly accurate first survey of India the first-named is best, and as a basis for the engraved general Atlas of India nothing could be more admirable. The muzawar or village survey affords a careful record of the village boundaries and a valuable check on the field measurements by the amins. But the cadastral survey, though it costs about three times as much as the second and seven and a half times as much as the first, has been pronounced by the Surveyor-General to be the cheapest of all considering the amount of information it gives. In the above rates the cost of publication was not included, and as this was so seriously heavy in the case of the cadastral surveys, a special branch, at a cost of Rs. 30,000 per annum, was added to the Photo-zincographic Office to meet the requirements of the 16-inch North-West Provinces surveys. In Bengal, on the other hand (where extensive tracts of country had been brought under irrigation by the Soane and other canals, necessitating fresh surveys for water assessment purposes), the fields were found to be generally so much smaller than in the North-West that it was necessary to increase the scale in some districts to 32 inches to the mile, a step which involved the production of four times as many maps for a given area as in the North-West Provinces, and an addition of Rs. 20 per square miles to the cost. In the Government estate of Khurdah, in the province of Orissa, the average size of the fields first surveyed was even smaller than in the Soane irrigation tracts, or only one-seventh of an acre. This and other causes raised the cost of settlement and surveying together to an amount equal to about six years' accumulation of revenue.

In 1877–78 the number of revenue parties was reduced to 11 full strength and two small parties, who worked in the following provinces, two *muzawar* parties in the Punjab, four cadastral in the

North-West Provinces, four in Bengal, two in Bombay, and one in Assam.

On the 31st December 1878 Major-General Vanrenen retired from the post of Superintendent of Revenue Surveys, after 39 years' service under Government, of which 32 had been passed in the Revenue Survey Department. When that branch of the survey was separated into two circles in 1866 he was appointed Superintendent of the Lower Circle, and subsequently on their re-amalgamation in 1876 he became Superintendent of Revenue Surveys. He left behind him many evidences of valuable work which had been carried out under his supervision, first as an executive officer, and afterwards as administrator of a large department. He was succeeded by Major J. Sconce, S.C.

The Punjab.—The Dera Ismail Khan, Bannu, and Rawal Pindi Districts Revenue or Muzawar Survey on the 4-inch scale was continued by Major-General Johnstone, C.B., up to the close of the season 1877–78, when he retired after 35 years' service, during 23 years of which he had been in charge of a party. General Johnstone is mentioned as a talented and able officer, with considerable experience of the frontier and the tribes inhabiting the same.

Two surveyors belonging to this party, Messrs. G. B. Scott and A. J. Gibson, were attached to the expeditionary columns under General Keyes and Ross into the Jowaki country, and with the exception of about 50 square miles of the hills occupied by the Hassan Khels (being the easternmost portion contiguous to British territory) the whole of this country was surveyed on the 4-inch scale. Captain Beavan and Mr. Scott also made a rough but fairly accurate map of the Kohat pass, with the hills, villages, and other adjacent features. In the following year the Bannu district was completed under Lieutenant-Colonel Macdonald, and the survey of the military camps near Murree was undertaken, in addition to the ordinary work, in 1881. In 1882–83 the *Thal* country of Muzaffargarh district, at the extreme south of the area of work, was taken in hand by one section of the party while the other surveyed the Kala Chitta Pahar, a wild gloomy tract in the north of the Rawal Pindi district, which a quarter of a century ago had a bad reputation as a place of refuge for robbers and murderers, but which has since settled down under the quieting effects of British rule.

This completed the work in the three districts of Dera Ismail Khan, Muzaffargarh, and Rawal Pindi, and in October 1882 Lieutenant-Colonel Macdonald and his party were transferred to the Hissar district of the Punjab. Here it was arranged that the survey should be on the 2-inch in lieu of the 4-inch scale, but including the survey of village boundaries and the determination of village areas. A special feature was the inclusion by traversing of points (to be marked permanently) in the interior of village lands at a distance of about half a mile one from another, so as to serve as a basis of a cadastral survey to be carried out by *patwaris** under the Settlement Department. This is something like the system of marks placed in the case of the British Burma cadastral surveys at selected stations where extensions of cultivation are likely to occur, but in Burma the marking has not been done in the same regular and systematic manner as in Hissar. Two sets of topographical maps were arranged to be drawn, one showing all the details as surveyed for reproduction on the 2-inch scale; the second set with the details somewhat generalised for reduction to the 1-inch scale. Village boundaries were to be shown on both sets of maps. The theodolite stations, after a good deal of discussion, were finally arranged to be marked by concrete blocks, which Colonel Macdonald caused to be manufactured under his own personal supervision. A receipt was taken from the patwari in every village for the number of blocks used in his village. The Hissar operations were completed on the 10th April 1884.

In the season 1884-85 the operations of the party (now in charge of Lieutenant-Colonel F. Coddington) were greatly modified. The objects of the survey were (1) to furnish a basis for and a check on the patwari measurements under progress in the Sub-Himalayan districts of the Punjab; (2) to obtain a new and revised series of the existing topographical maps, which were very old and deficient in details, by utilising the settlement maps prepared by the patwaris; (3) the survey of all the riverain tracts subject to fluvial action. To these ends the following procedure was agreed upon, viz., (*a*) that in the districts which had been recently surveyed by the patwari agency an attempt should be made to construct topographical maps on the 2-inch scale from the patwari maps on the basis of the old professional survey traverse data; (*b*) that in districts in which the patwari survey had not yet been made,

* Village accountants who keep the land records of the village.

skeleton traverses should be run, fixing as a minimum two points in each village to serve as checks on the patwari measurements, and as a basis on which the topographical maps could be framed from the patwari maps when constructed; (c) that the topographical maps so compiled should be locally tested and the details corrected and completed when necessary. The work lay in the districts of Firozpur, Jalandhar, Ludhiana, and Umballa, and in the Kapurthala State, and the result of the year's experience was to show that the patwari maps of the settlement survey were capable of being utilised for the construction of topographical maps on a small scale when based on a scientific framework comprising all the trijunction marks of villages. The errors of survey were not greater than such as became eliminated in the process of reduction.

In 1885–86 work was pushed forward in each of the above-mentioned districts, as well as in Gurdaspur and Hoshiarpur. The reductions from the settlement survey maps when tested were found to be very correct representations of the ordinary topographical features, and only a few omissions had to be supplied by new surveys. During this and the following seasons up to 1888 the nature of the detailed work was thus described:—

(1.) The skeleton traversing of villages for the purpose of determining the co-ordinate distances of trijunction points, and the projection of maps of the trijunctions on the scale of two inches to the mile.

(2.) The insertion of topographical details on these maps by reduction from the settlement survey village maps.

(3.) The testing and correcting (where necessary) the reduced maps by examination in the field.

(4.) The drawing of fair maps on the 2-inch scale.

(5.) The re-drawing of the old 1-inch maps of the Sikh States to complete the portions of those territories falling within the present continuous series of standard maps.

Reductions to the scale of the Atlas of India have been drawn from all the standard-sized sheets compiled, covering a total area of 11,880 square miles, and furnishing materials for the revision of six of the engraved plates of the atlas.

Captain E. H. Steel's party (No. 2 Revenue), completed the 4-inch village survey of Rohtak in 1876–77, and continued that of Sirsa in that and the following season, rendering an excellent out-turn in 1877–78. The cultivated tracts close to the rivers were often

difficult to distinguish, for land which to an ordinary traveller would appear nothing but a sandy waste is often a mass of cultivation, and barley may be seen forcing its way up through several inches of drift sand. In the following season the survey of Sirsa was completed, and the party abolished in accordance with the reductions then determined on.

On the completion of the Ganges Dearah Survey, Major Wilkins's party was transferred to the district of Saharanpur, in the North-West Provinces, for the purpose of re-surveying it on the 2-inch scale (in connexion with other districts of the North-West Provinces), so as to show the pargana or fiscal boundaries, the village trijunction masonry platforms being used as theodolite stations for the traverse survey, and the village boundaries being inserted from the settlement maps. As the survey was for topographical purposes and not as a check upon settlement operations, it was held unnecessary to crowd in minute details of cultivation, culturable waste, or jungle lands, and it was arranged that the survey should include large patches of waste, barren as well as culturable, the general outlines of cultivation, tracts of jungle, limits of forest reserves, roads, drainage in all its ramifications, tanks, village sites, temples, embankments, &c. In short the same details as those required in the usual village by village 4-inch *muzawar* survey, but *generalised.* The Government forest lands having been elaborately surveyed by the Forest Survey Branch on the 4-inch scale from the Siwaliks to the base of the hills, there was no necessity for going over this ground. The details of the two surveys where they met agreed on the whole very well. The traverse survey was connected with four principal and nine minor stations of the Great Arc Series, these being all that could be identified, a matter which could cause but little surprise, considering that 50 years had elapsed since the triangulations took place. Endeavours were made to use the azimuths of the sides of the principal triangles, but the heliotrope flashes could not be seen, the probable reason being that the view was intercepted by trees that have grown up during the last 50 years.

During 1878–79 the survey of the Muzaffarnagar district was commenced, and that of Saharanpur district was completed with the exception of the village boundaries on the Jumna and Ganges rivers, which were adjusted and mapped during the following year. A 4-inch survey of the riparian villages in the Umballa district was

also undertaken, so as to supply accurate maps of the alluvial valleys adjoining some of the larger rivers, which would show village boundaries and the course of the stream, with the accretion and decretion of lands since the last surveys were made. The Muzaffarnagar district was completed during 1879–80, and the special survey on the 4-inch scale of the villages subject to fluvial action was extended so far as the Jumna forms the common boundary of the Karnal district of the Punjab and the Meerut district of the North-West Provinces.

The success of the system of transferring the village boundaries from the settlement field maps to the survey maps was found to depend entirely on the accurate identification of the points adopted as trijunctions of village boundaries by the settlement survey. In 1880–81 the topographical survey operations were continued in the Meerut district as well as the 4-inch survey of the line of villages on both banks of the Jumna river. In the following year Major Wilkins was transferred to Burma, and, after a brief interval, Mr. E. T. S. Johnson assumed charge. The work was continued on the same lines as in previous seasons, and areas were traversed in districts Bulandshahr and Aligarh, in preparation for the next year's topography. Mr. Johnson retired on the 29th April 1883, after a lengthy and useful service under Government. After Aligarh, Etah district was next undertaken, but at the close of the season the work was suspended, as the Government arrived at the conclusion that the existing revenue settlement maps, in spite of their imperfections, would answer all revenue requirements, and that surveys in other provinces were more urgently required. The party was therefore withdrawn from the Etah district, and it was arranged that they should be employed in the ensuing season on the Ajmir-Merwara district boundary survey.

North-West Provinces.—The revenue survey of Moradabad in 1876–77 was on the cadastral system, which is described at pages 182 and 183 of Mr. Markham's "Memoir on the Indian Surveys" (2nd edition). The scale was 16 inches to the mile, and the work was connected with the fixed points of the Great Trigonometrical Survey. The operations were also extended into District Budaun, but here the scale was reduced to four inches to the mile, and the survey was of the ordinary *muzawar* or village by village character. The cadastral measurements in Moradabad were completed in 1877, and the village survey of Budaun in the ensuing year. Ghazipur was the

next district taken in hand, but here it was decided that the 16-inch cadastral scale should be reverted to. Various improvements in the procedure were devised, one being a change in the scale of the general maps reduced from the cadrastral surveys, from four inches to two inches to the mile, and an alteration in the style in which they were drawn, admitting of their being further reduced to the 1-inch scale in the photographic office at Calcutta, without the necessity of being drafted afresh. Another improvement effected was that no field books of field measurements were prepared, the measurements being plotted instead on the original plans at once in the field, while the Settlement Officer, instead of being supplied, as formerly, with skeleton *khusras*, or field registers, was supplied with copies of the field area calculation books, which required no additional labour in their preparation, as they are made in duplicate. It was calculated that from these two simplifications, viz., doing away with the field books of measurements and the *khusras*, about 100 additional square miles were surveyed during that season, and the cost of the work was reduced by 30 rupees per square mile. In 1882 Ghazipur was completed and Ballia (commenced in the previous season) was continued, but in the case of some of the villages in the latter district, the small size of the fields necessitated an increase in the scale to 32 inches to the mile. A 4-inch survey of a line of villages in the Shahabad and Sarun districts of Bengal, on the banks of the Ganges, and Gogra, opposite to Ghazipur and Ballia, was also put in hand, the Government of Bengal having taken advantage of the presence of the survey officers to have a reliable map of the low-lying country liable to inundation, with full details of the village and estate boundaries, in one series of maps for both provinces.

In 1882–83 the operations had reached the Benares district, and here a very important change was introduced, in that the field surveyors, who hitherto had prepared maps only, had now the duty assigned to them of also writing the *khusras* or field registers, including the names and record of rights of the proprietors and tenants. The additional work of *khusra* writing had already been given during the preceding season to the cadastral party employed in the Mirzapur district, but there the system differed somewhat from that adopted for Benares. In Mirzapur the *khusra*-writing and nothing more was done during the season of survey, the *jamabandi**

* Rent-rolls showing the numbers of the fields belonging to each tenant, and the rents.

slips being compiled from the *khusras* during the ensuing recess, and both *khusras* and slips being then completed by having the field areas entered in them. The papers were then ready to be handed to the settlement staff, who took the field the following season to attest the *jamabandi* entries, and complete all other papers connected with the record of rights. The Benares system was for the settlement staff to take the field along with the survey staff, and for the two departments to work in co-operation, so that all the papers could be prepared in one season. Briefly stated the system was:—1st, the settlement staff supplied the survey *amins* with such information as would enable the entries in the *khusras*, regarding the shares of the proprietors and the occupancy rights of the cultivators, to be correctly recorded. 2nd, the village patwari accompanied the amin during the survey, and wrote a copy of the *khusra* exactly similar to the amin's copy (except that it was in the Nagri instead of in the Persian character), writing also concurrently in the *jamabandi* slips, which had been previously distributed to each cultivator, the "numbers" of the fields as they were surveyed. 3rd, the *patwari's* copy of the *khusra* and the *jamabandi* slips were at once made over to the settlement staff, with a manuscript tracing of the village map to allow of any disputes being settled. 4th, the computations of field areas were then carried out in the survey office, so as to complete the Persian copy of the *khusra*, which was then made over to the settlement staff, who in due course transcribed the areas on the *jamabandi* slips, and thus prepared these for final attestation. The exact procedure is explained in a joint memorandum drawn up by Mr. F. W. Porter, Settlement Officer, and Major W. Barron, Deputy Superintendent of Survey, which is given at page 88 of the appendix to the Surveyor General's Report for 1882–83.

After six months' trial of the system, these two officers submitted reports on its working, showing conclusively that very great advantages ensued from the joint inter-working of the settlement and survey staffs, while the additional duty of khusra-writing did not add to the cost of the survey.

In 1883–84 Basti district came into the field of operations, and Major W. Barron, who had conducted the work for several years with great zeal and ability, was granted furlough to Europe through ill-health, Mr. G. H. Cooke, first, and Major S. H. Cowan, next, assuming charge. In 1884–85 certain modifications were introduced

into the Benares system, and the entire preparation of the rough record, including the Hindi portion, and all such assessment statistics as could be compiled with sufficient accuracy previous to attestation, were made over to the Survey Department. The settlement decided to retain, however, a staff of settlement *munsarims** to check the soil demarcations and the records of certain villages as they were being written, and to submit special reports on the accuracy of the *khanapuri*.†

The cadastral survey of the Basti district was completed in 1888, having been begun in 1883-84. The total number of villages was 7,615, the area in square miles was 2,815, and the number of fields 5,260,420. Regarding the value of the village papers prepared by the survey party during previous seasons, the Settlement Officer of Basti, in illustration of the satisfactory manner in which the rights of the occupancy tenants were safeguarded on this occasion against the designs of the zamindars, prepared a table for five parganas, viz., Amonha, Nagar West, Nagar East, Basti West, and Basti East. The tabular statement of the total areas for these five parganas recorded in the papers of different "Fasli" years were as follows:—

AREAS HELD BY OCCUPANCY TENANTS.

According to Annual Statements prepared in the Office of District Sadar Kanungo.			According to Survey Records after Attestation by Settlement.
F. Year 1289.	F. Year 1290.	F. Year 1291.	F. Year 1292.
53,766.	67,180.	44,650.	100,199.

From the above it will be seen that the total area was far less in the year 1291 (the year before survey) than in previous years, which shows that the zamindars had got the *patwaris* to enter a number of occupancy tenants as "non-occupancy" tenants, in the hope that they would be similarly recorded by the survey. The figures for 1292 show how eminently successful the new and accurate system of survey was in defeating this fraudulent attempt.

* Inspectors.

† Filling up the columns of the *khusra.*

Besides the Basti operations, cadastral and topographical surveys by three sections of the same party were carried on in Mirzapur district. The *patwaris* were here trained and partially employed under professional supervision, so that they might be capable of measuring the fluctuating cultivation year by year or as might be necessary.

Under the supervision of Colonel F. C. Anderson, No. 5 Revenue Survey party was engaged in 1876–77 on the cadastral survey of the Mathura and Banda districts of the North-West Provinces. During the following seasons the permanently settled district of Mirzapur as well as portions of the Terai were also surveyed by the same party up to 1883, when Colonel Anderson retired. He had been connected with the Department for 31 years, and had held charge of No. 5 party for 27 years, during which he had conducted the 4-inch surveys of districts Leiah, Muzaffargarh, and Shahpur in the Punjab, and districts Partabgarh, Rai Bareilly, Sultanpur, Sitapur, Kheri, and Gonda in Oudh; and had been connected with the departmental cadastral surveys since their introduction in 1871–72. In 1860 Colonel Anderson was appointed one of two British Commissioners for the settlement and demarcation of the boundary between Oudh and the territory ceded to Nepal, and received the thanks of the Government of India for his services on that occasion.

The party was then transferred to Gorakhpur district, North-West Provinces, where Major J. E. Sandeman assumed charge, the system of survey and record writing being generally that followed in Benares, with this important modification, that—

(1.) The Survey Department completed the records and was responsible for their accuracy.

(2.) The attestation was made after the completed records had been lodged.

It was felt that it was a defect in the Benares system that the attestation of the records had to be done before the areas were entered. This was remedied in the Gorakhpur system, while there was a great check on bribery and corruption from the fact that the patwari prepared a duplicate record on the spot for every field and a duplicate of the dispute list. These modifications were devised by Mr. J. D. La Touche, Settlement Officer, and Major Sandeman. The classification of the natural soils was undertaken for the first time by the Survey Department, who had also to compile the statistics

for assessment purposes comprising the soils, irrigated and dry; the details of soils under cultivation; the tenures of the holdings; the culturable and barren areas; the areas under different crops; the cultivators, showing the numbers in each caste and the areas cultivated by each caste, and all agricultural statistics with respect to wells, ploughs, cattle, &c. The duties and responsibilities of the survey officers were much increased by these arrangements, but there was every prospect of an increase in the accuracy of the records and eventual economy. The boundary disputes were very numerous during the following season (1884–85), no less than 1,800 of the villages surveyed being affected thereby. These disputes appeared to be due to the old defective field maps, which when adjacent invariably overlapped each other, so that the same ground appeared in both, and much litigation and ill-feeling was thereby caused among neighbouring zamindars.

The total cost of the operations done by the Survey Department amounted in 1884–85 to 4 annas 3 pies per acre, a rate which compared very favourably with the old rate for field survey alone. This was not due to larger fields, for the average size of those in Gorakhpur was only half an acre, but it proved what survey officers have always urged, that the work would be done not only better but more cheaply if the Survey Department recorded the rights of proprietors and tenants at the time of survey, for it has been conclusively proved that correct field boundaries cannot be obtained otherwise, as the people will not attend unless they know that their rights are being recorded. The expenditure of the Settlement Department was exceptionally high, due to complicated tenures, minute holdings and numerous disputes, and this served to raise the cost of the complete operations to Rs 410 per square mile.

The survey was continued on the same lines in 1885–86, but in 1886–87 an endeavour was made to employ the district *kanungos** in place of the survey munsarims; the experiment however failed, as the men were found to be too ignorant for the purpose. Here, again, in the case of one *tahsil*,† the survey operations resulted in the discovery of twice as many occupancy tenants as had been returned by the kanungos four years previously, the fact being that the presence of European surveyors encouraged the tenants to assert their rights more fearlessly than they could otherwise have done. The survey of

* Revenue official under the tahsildar.

† Portion of a district divided off for revenue purposes.

Gorakhpur was completed in 1887–88 after five seasons' work, and a further grant was sanctioned by the North-West Provinces Government which it was expected would enable the cadastral and topographical survey of the Tarai district, already commenced, to be finished during the next season. A scheme, submitted by Colonel Sandeman, was also approved for the reconstruction of maps and revision of records of the Jhansi district, entirely through the agency of *patwaris*, who, it was anticipated, would carry out the survey and write the records, each in his own circle, in two years. The cost was estimated at Rs. 40 per square mile.

Bengal.—The Eastern Soane Irrigation cadastral survey in the Gaya and Patna districts was practically all but completed by Mr. E. T. S. Johnson in 1876–77, and the party transferred to the North-West Provinces to take up the cadastral survey of the Jaunpur district, beginning at its south-western extremity, bordering on Oudh and Allahabad. Operations were continued through four seasons, and finally concluded in 1881. The general maps of the district reduced from the cadastral sheets consist of 23 standard-sized maps on the 2-inch scale.

A part of the establishment previously employed on the Jaunpur cadastral survey was deputed to Sylhet for the purpose of testing the accuracy of the old *mahalwar** maps, prepared by a local establishment in 1862–64. Three blocks of villages in different parts of Sylhet were selected, the test consisting of a complete cadastral or field survey, while the surveyors were required to prepare at the same time the village registers or *khasras*. The old surveys had been laid off by magnetic bearings, taken at each bend of the *thakbust* or village boundary, a system which often resulted in errors, so that the polygon would not close, while contiguous *mahals** either overlapped or would not meet on the map. It was evident from the comparisons that a large amount of careful and laborious work had been done during the mahalwar survey, but there were also numerous and large discrepancies brought to light.

A cadastral survey of the Khurdah estate in the Pooree district of the Lower Provinces, on the scale of 32 inches to the mile, was commenced in 1876–77. The cost was high owing to the small size and intricate nature of the fields, and the difficulty in inducing

* *Mahal*, a separate estate.

the Ooriyas or men of the country to act as *amins*. The operations were in charge of Mr. R. B. Smart, an officer of considerable experience. In 1878–79, however, the Bengal Board of Revenue, on account of the high cost of the operations, advocated a new system, under which a large portion of the work hitherto performed by the professional party would be undertaken in future by the Settlement Department. A meeting of civil and survey officers consequently assembled at Cuttack in February 1879, and after consideration a still larger transfer of duties to the Settlement Department than at first contemplated was decided upon, it being arranged that for the remaining villages of the Khurdah estate the professional party should execute a traverse survey of the village boundaries and prepare skeleton maps of villages. These skeleton maps were to be made over to the Settlement Department to enable them to carry out all interior measurements. But any hills falling within the villages were to be surveyed by the professional party on the 4-inch scale. The chief tract remaining for survey in 1879–80—the *mals* or forest lands of Banpur—was known to be at all times unhealthy, and during that season everyone who entered the jungles was sooner or later struck down with fever. These *mals* had never before been demarcated, and the inhabitants of the scattered hamlets had hitherto cultivated the open patches of land without let or hindrance, escaping all taxation. It was not surprising, therefore, that they looked upon the survey as an innovation, and as far as possible avoided giving help, but thanks to the efforts of the Collector all difficulties as to supplies, &c. were surmounted. The whole of the Khurdah estate was completed during the season of 1879–80, the general maps on the 4-inch scale being 65 in number, of which 48 were surveyed by the Department and 19 by the Settlement Department.

The 8th or Western Soane Irrigation party was engaged in 1876–77 on cadastral surveys in the Shahabad district. It was supposed that the entire irrigable area of the district would be surveyed, but during October 1877 the programme was changed, and the area in Shahabad was greatly reduced. Major Sconce was in charge of the party as well as of a section left to complete the cadastral survey of Patna district, and under his general supervision the work in both districts was completed.

Major S. H. Cowan, who had assisted Major Sconce, was deputed during the following season (1878–79) to raise a small party for

the survey of Cachar, and with the nucleus of some men from the Western Soane party this was done. The operations in Cachar had become necessary on account of the pending re-settlement of the district, but owing to the old boundaries not having been permanently marked they could not be identified on the ground. Consequently a settlement establishment had to precede the professional survey party, demarcate the *mehal* boundaries, and prepare maps of the boundaries by aid of the compass and chain for comparison with the maps of the cadastral survey. Under these circumstances the out-turn was not large, and after a conference at Shillong it was decided that in future the professional basis of the village boundaries of the cadastral maps should be continued through the agency of a small professional detachment under the orders of the Settlement Officer.

In the Midnapur district a 4-inch survey muzawar was progressing in 1876–77 under Mr. W. Lane, who retired early in the season after a useful and lengthy service of nearly 40 years, and was succeeded by Captain W. H. Wilkins. At the close of the season a very small area in the jungle Mehal hills was all that remained to complete the district, and this was assigned to Mr. J. Todd for the next year, the rest of the party being reconstituted for a cadastral survey of the irrigable lands of Cuttack in the vicinity of the Mahanadi river. The survey was undertaken for the Irrigation Branch of the Public Works Department to facilitate the collection of canal water rates, and the entire expense was defrayed by that Department. Captain D. C. Andrew was placed in charge till he was invalided by a sun-stroke and succeeded by Mr. E. C. Barrett. Operations were much delayed by the fact that the demarcation had not been pushed forward and disputes had not been adjusted in advance, but the survey was finished in 1879, the greater part of the work being on the 32-inch scale.

In November 1879 a cadastral 16-inch survey of the Bassein district of British Burma was started under the superintendence of Major D. C. Andrew. The country is largely intersected with creeks, all communication is necessarily carried on by water, and boundary lines had to be very frequently cleared through dense jungle. Major Steel, who had charge in the following season, reported promisingly of the Burman and Kareni surveyors, but this favourable opinion was not endorsed by Majors Wilkins and Hutchinson in the succeeding years, as they found them slower than

Hindustanis, and without much ambition to become useful. A school for the training of Burmans as surveyors was established, and 89 youths qualified themselves by field training in the principles of filling in cadastral survey details, the British Burma Government having made the possession of this certificate a *sine quâ non* to civil employment, but Major Hutchinson did not come across a case of a Burman desiring to make field surveying a means of livelihood. In 1882–83 the survey of the town of Bassein on the 64-inch scale, at the expense of the municipality, was undertaken, and in the following season operations were extended into the Henzada district, the surveys of both districts being brought to a close in 1885. The party was then transferred to Behar to inaugurate an experimental cadastral survey of the Muzaffarpur district under Lieutenant-Colonel Barron, Major Hutchinson being transferred to Akyab.

The cadastral survey of Muzaffarpur in Bengal, with preparation of a record of rights, was undertaken experimentally under the Bengal Tenancy Act, and as the operations were of considerable importance, involving as they did the great question of a thorough statistical and geographical survey throughout the permanently settled districts of Bengal, a brief account of the circumstances which led to the institution of the survey is here desirable.

The Indian Famine Commission, who reported in 1880, had laid special stress on the necessity of appointing village accountants in Bengal, and of instituting cadastral or field surveys in the same province.* This weighty matter, closely connected as it was with the question of the relations between landlord and tenant in Bengal, very soon branched off from the more general recommendations of the Commission, regarding the establishment of Agricultural Departments and the organisation of famine relief, and became the

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* "We recommend that the body of village accountants should everywhere be put on a sound and satisfactory footing as responsible public officers, with a clearly defined set of duties, but with due consideration to the importance of their permanent connexion with their own villages, and that whereas in parts of Bengal and Sindh the class has ceased to exist through long desuetude it should be resuscitated. . . . . . The field survey, which supplies the basis of all agricultural statistics, should be pushed on in the provinces where it is now in progress, and should be set on foot in Bengal, where hitherto it has not been introduced. In that province the expenditure, or the major part of it, should be borne by the landholders, who alone derive advantage from the increasing value of the land, and who cannot without such a survey properly perform the duties imposed on them by their position." (Command Paper C.–2591, 1880, p. 40.)

subject of an important and lengthy correspondence spread over several years between the Government of India and the Secretary of State. The experiment of a cadastral survey and of the establishment of village records in the Patna division of Behar was sanctioned by Lord Hartington in 1882,* but pending the larger question of the amendment of the Bengal Rent Law, nothing was done to give effect to that sanction. In 1884, Mr. Reynolds, one of the members of the Bengal Board of Revenue, submitted a full explanatory memorandum (based largely on a note of Mr. Bernard) describing the proposed survey and record of rights, and also the proposed *maintenance* of the survey and records by introducing into Behar the North-west Provinces system of *patwaris* and *kanungos*. For this purpose a Patwari Bill was brought into the Bengal Legislative Council, and the survey and record operations were started in the district of Muzaffarpur. But in 1886, Lord Randolph Churchill, who was then Secretary of State, in reviewing the whole situation, expressed his opinion† that the cost of survey and record operations in Muzaffarpur should be borne wholly by the Government, on the ground that "as the measure at present is purely "experimental it would not be right to lay any part of the expense "on the people." At the same time, Lord Randolph made a reservation as regarded the cost of the patwaris, which he had no objection to see defrayed from local funds if there were found any "existing customary source" capable of being made fairly available for the payment of the new class of village accountants. The Government of India, however, in their reply plainly objected to this new idea of defraying the expense from general revenues, so that Lord Kimberley, who had in the meantime taken office, thought that there was no choice left but to abandon the survey, which was accordingly done.‡

The stoppage of the survey gave rise to much general regret. It had been desirable, in the first instance, to test the feelings of the people in Behar with regard both to mapping the holdings and to the concurrent inquiries into occupancy rights, as well as to ascertain the probable cost of the operations with the view of

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* Despatch No. 54 (Revenue), dated 17th August, p. 190 of volume of Selections from Despatches for 1882.

† In his Despatch No. 1 (Legislative), dated 7th January 1886.

‡ Despatch to Government of India (Legislative), No. 21, dated 15th July 1886.

their being extended, if matters should be found favourable, to other permanently settled districts of the Lower Provinces of Bengal. The result of the experiment, so far as the temper of the people was concerned, had been in every way satisfactory. The landlords offered no opposition, as had been feared they might have done, through their regarding the formal recording of the rights of the tenants as a restriction of their proprietary rights. The tenants did not object, as had been partly expected, to the measuring of their fields, through apprehension of an increase of rents, though it was also evident that they were still ignorant of the great advantages accruing to them from the accurate record which was being made of their holdings. Generally they were found to be passively indifferent to the operations. The cost of the survey had been at the total rate of Rs. 269 per square mile, being Rs. 140 for survey proper and Rs. 129 for writing and compiling the records. These rates, however, were exceptionally high, owing to the operations being new, and several of the hands untrained. For the ensuing season it was confidently expected that the cost would have been reduced to less than Rs. 200 per square mile, or below 5 annas per acre.

But so useful and important a measure was not destined to be permanently abandoned, and the subject soon came to the front again. The Government of India, on inquiry into all the circumstances, arrived at the same conclusion as that formed by the Surveyor-General, that the experimental survey in Muzaffarpur had really been a success and deserved to be extended.* And when the matter came before Lord Cross, as Secretary of State, he accepted this favourable opinion, and finally reversed the decision of Lord Randolph Churchill as to the cost in the following terms: "I fully "agree in your opinion, that if the work is undertaken at all the "cost of the survey and of the subsequent maintenance of the "village record must be kept within the narrowest possible limits "of cost, as the expenses will have to be defrayed by the classes "and localities concerned."†

There is therefore every prospect that this survey will be resumed as soon as the people have recovered from the loss caused by the scarcity of 1889. A beginning will thus be made with a proper cadastral and statistical survey of the permanently settled districts

* Sir E. Buck's letter to the Government of Bengal, dated 16th June 1888.

† Despatch to India, No. 66 (Revenue), dated 16th August 1888.

of Bengal, which has been hitherto one of the most urgent preliminary desiderata for acquiring a thorough knowledge of the resources of the country, and thus minimizing the devastations of famine.*

The Dearah Survey, on the 4-inch scale, in the districts of Faridpur and Bakarganj was continued and brought to a close in the year 1876–77, the operations lying mainly adjacent to the Megna river, where the country consisted partly of heavy jungle and partly of densely populated tracts with bamboo, betel, and cocoa-nut groves, and innumerable tanks. One of the principal objects of the survey was to fix and render permanent the village boundary trijunctions on and adjoining the large sand-banks and islands, and 536 of these were so fixed during the season. The weather throughout was unusually wet and stormy, and as the country under survey consisted of sand-banks and islands intersected by immense rivers, the crossing of these in small country boats is a matter of no small risk. Captain Samuells, who was in charge, stated that the zemindars obstructed the survey as much as they could by refusing to attend or point out their boundaries until summoned to do so. The process of summoning caused a delay of 15 days, when an agent would be sent to attend, who either pointed out a wrong boundary or professed entire ignorance and finally told the surveyor to put down any boundary he pleased.

It was arranged that the party should undertake, during the following season, the topographical survey of district Saharanpur, one of the 21 districts of the North-West Provinces, of which most of the records were destroyed in the Mutiny. The scale of survey was to be two instead of four inches to a mile. Village boundaries were to be omitted, but *pargana*† and *thana*‡ boundaries were to be surveyed and mapped.

In 1888–89 no fewer than seven parties and one detachment were altogether employed on cadastral surveys. Of these six continued the operations of the previous year in the Bilaspur district of the

* Compare the paper on Indian Agriculture, read by Mr. C. R. Markham, C.B., before the Society of Arts, on the 21st May 1875:—"When we find the cultivators well off in "one district, depressed by poverty and want in another, or on the verge of starva-"tion in a third, we may feel sure that these differences are to a great extent due to "want of exact knowledge on the part of the rulers." And Mr. Markham goes on to point out very clearly that a cadastral survey is the only satisfactory basis for acquiring such knowledge.

† Subdivision of a district for revenue purposes.

‡ Subdivision of a district for police purposes.

Central Provinces (where the work was brought to a conclusion), in Bengal, the North-West Provinces, Assam, and Burma, while the seventh party was transferred from the North-West Provinces to start the survey of Jalpaiguri in Bengal. A small detachment was also formed for the commencement of the survey of Chittagong.

Traverse surveys in the Punjab and Central Provinces were also carried on by six parties, those in the former being occupied in the construction of topographical maps by reduction from the village maps of the settlement surveys, and those in the latter in furnishing skeleton plots of villages for field surveys by *patwaris* working under settlement officers. Four parties were also engaged in forest surveys in the Central Provinces in the Bombay and Madras Presidencies and in Lower Burma respectively, as well as a detachment in Bengal working in conjunction with the cadastral party engaged in the survey of Angul in Orissa.

Hugli River and Calcutta.—The want of a reliable survey of the Hugli river had been long felt, and had been pointed out by the Torpedo Committee in 1871, by the Bengal Chamber of Commerce in 1872, by the Port Commissioners in 1875, and finally by the Port Officer of Calcutta, who had shown in 1881 that an exact triangulation and topographical survey of the banks of the river were also much needed as a basis for new river charts, and that the co-operation of the Survey Department was desirable. The Surveyor-General of India accordingly took advantage of the completion of the cadastral survey of Jaunpur district to depute the party to take up the work on the Hugli. The tract to be surveyed on either bank varied from a quarter of a mile to a mile or more in width, and extended from about the 23rd parallel, near Kanchrapara Station of the Eastern Bengal Railway, to close on 22° 30′, or about the latitude of Saugor lighthouse. Calcutta and its suburbs as well as the whole of Saugor island were included in the area. From Atchipur southwards the scale adopted was six inches, while above Atchipur it was 16 inches to the mile. The river soundings which did not extend above Calcutta were supplied by the Marine Survey Department under the supervision of Lieutenant Petley, R.N. The Hugli survey was completed during the season of 1882–83 by Major S. H. Cowan, the 16-inch portion being contained in 115 sections of uniform size, including one minute of latitude by one minute of longitude, and the 6-inch series comprising 14 maps.

In consequence of the growth of the capital, a re-survey of Calcutta had become necessary, the former plan, executed in 1847, by Mr. F. W. Simms, C.E., having been on too small a scale, and having since become quite out of date. In 1851 a survey of the boundary of holdings was commenced by Mr. W. Heysham, whose work lasted four years, and who converted Mr. Simms's topographical maps into maps showing the holdings, with index numbers referring to a register of owners and areas. These, however, in process of time, had become useless through changes in proprietorship, but a newer and more correct set of registers had been begun in 1877.

The "Calcutta Survey Act, 1887," became law on the 15th January in that year. The Deputy Superintendent in charge of the operations was empowered to inquire into and lay down boundaries. The scale adopted was 50 feet to 1 inch, surface features being shown with the greatest minuteness, and the underground lines of sewers, gas, and water pipes being subsequently added. There has been a great deal of delay caused by the failure of proprietors to attend when their boundaries were being laid down, and there is still a good deal of work remaining to be done, including the house to house inquiry as to names of proprietors and boundaries of buildings, and the drawing of the fair sheets. The principal field work has been completed, but owing to the great difficulty in getting proprietors to attend, when the boundaries are being laid down, it is almost impossible to say when the last sheet will be published.

Bombay.—Owing to the famine the operations in 1876–77 of Major H. C. B. Tanner's party in the Poona and Satara districts had to be diverted to a part of the country which was quite unprepared for survey, and where no triangulation had been done in advance, and this resulted in a smaller out-turn than usual. The nature of the survey was, as before, topographical, on the scale of two inches to a mile, based on triangulation and traverse. The levels and charts carried out by the irrigation officers were incorporated into the survey sheets, and all the heights were connected with those brought up from the coast by Captain Baird's Tidal and Levelling party, so that the true heights above mean sea-level were ascertained in each case. Every effort was made to utilise the maps of the Bombay Government Revenue Surveys, but as the work in this year happened to lie in hilly ground, where these maps were found to be, as a rule,

defective, the efforts were unsuccessful, though good use was made of them in the succeeding season. In 1878–79 Major Tanner was employed with the Khaibar column of the Afghanistan Field Force and Major H. S. Hutchinson took charge of the South Deccan party. For one of the southernmost sheets (54) the scale of survey was increased to four inches to the mile; but in other parts the old 2-inch scale was adhered to.

Major Hutchinson found it impracticable to utilise the topography of the Bombay maps, owing to the drainage and other items being imperfect and varying much in quality in different localities, according to the time at which it was done and the officer who did it. In 1880–81 the opportunity was taken by Major Andrew, who had assumed charge, to survey some western portions of the Nizam's dominions which adjoined the area of the party, as no maps were forthcoming of the tract among the records of the old Haidarabad Survey. The general work was steadily continued up to 1886, when the South Deccan party was withdrawn from the Bombay Presidency and transferred to the Central Provinces to carry on a traverse survey there in aid of a settlement survey. It had been employed in the Bombay Presidency since October 1872, and during the 14 seasons of its employment had surveyed in all, under successive officers, a total area of 24,867 square miles, leaving about 11,953 square miles incompleted.

The 10th or Nasik, Poona, and Ahmadnagar party, under Major Macdonald, was occupied in 1877 in topographical survey in Ahmadnagar district, the eastern part of which adjoined Haidarabad territory. The country was generally flat and open, though here and there intersected by a network of large and small streams. In the west the ground was broken and undulating, while in the immediate vicinity of the Ghats it was a mass of hills, some very rugged and precipitous. The skeleton survey was a combination of triangulation and traversing, by which the country was first covered by a network of triangles having sides averaging 10 miles in length; the distances between the triangulated points were then traversed with the chain, thus enclosing main circuits, of which the bearings and co-ordinates obtained by traverse were corrected to agree with the values of the points derived from the triangulation. The city of Ahmadnagar was mapped on the scale of 66 feet or one chain to the inch for the municipality, by whom the extra cost was defrayed. An excellent

descriptive report of the Deccan, its appearance, physical geography geological structure, chief towns, ports, manufactures, &c., is attached to the Surveyor-General's Report for 1877–78.*

The area allotted to this party having been nearly completed, the survey of the Konkan or country between the Western Ghats and the sea was assigned to them in January 1879. The system and scale of survey (2-inch) were the same as those adopted for the Deccan topographical survey, and the triangulation was based on the South Konkan Meridional Series of the Great Trigonometrical Survey. Triangulation was carried on under great difficulties, as the agriculturists burn the village refuse to supply ashes for the rice fields. The smoke of the fires added to the dense atmosphere near the sea coast covered the tops of the hills with a dense haze, and after 10 in the morning even the luminous signals were not visible for over six or eight miles. The Deccan dacoits too roamed about the country cutting down signals and destroying marks.

Captain E. W. Samuells was in charge of this party up to the 11th September 1878, when he availed himself of two months' privilege leave to recruit his health. Before the termination of his leave the Afghan war had commenced, and he and Major Tanner had to accompany the Khaibar column. Captain Samuells, after narrowly escaping from the enemy's artillery fire while surveying during the battle of Ali Musjid, fell a victim to fever on the 21st December 1878. He had entered the Department in December 1863, and had held charge of different parties for about six years altogether. He had served in Bengal, Assam, the Deccan, and on a special boundary survey of the Oudh and Nepal frontier, and was an energetic and zealous officer.

In 1879-80 the North Deccan party was divided into two sections, one being engaged in completing the portion of the Deccan allotted to the party, with which was included the Ashti taluk of the Nizam's dominions, as it is surrounded by Deccan country. The second section commenced the topographical survey of the Konkan, where preliminary triangulation had been done during the previous season. The 2-inch scale was continued as in the Deccan, but the village boundaries were obtained by direct survey, as it was found that the transfer of the boundaries in such hilly country from the Bombay Revenue Survey maps would not have been satisfactory.

* Appendix, p. 129.

A picturesque description of the Konkan, from the pen of Colonel J. Macdonald, finds place in the Surveyor-General's Report for 1879-80.* Colonel Macdonald remarks on the few remains of fine buildings throughout the Konkan, showing the traces of Muhammadan occupation, and he observes that, considering the importance they attached to the trade and intercourse with Egypt, Persia, and Arabia, and that they were supreme in power from the fourteenth to the close of the sixteenth century, it is strange there are not more traces of a governing race which built like giants and finished like jewellers. Of the Marathas, who date from the middle of the seventeenth century, the great hill forts are the most characteristic structures. All these are constructed on the same principle, the top of the fortified hill being surrounded by a bastioned wall, and any necessary outwork being connected by an excavated passage with the main work. Some of these forts show stupendous labour in rock-cutting. The eastern districts are terribly denuded of forest trees. Every effort is made to promote jungle growth, but Colonel Macdonald considers that centuries must elapse ere the injury to agriculture caused by the folly and greed of one unthinking generation can be quite forgiven by nature, and that the rainfall in the upper basin of the Godavari and Kistna rivers will be most precarious for many years to come.

The progress was slow in the following year owing to the high and difficult hills covered with forest or marshy flat country cut up by tidal creeks, about which the work lay. The suburbs of Bombay were very intricate, and the hill sanitarium of Matheran and Bombay harbour also proved difficult pieces of work. The fort and city were not surveyed, but mapped from a photographic reduction of Colonel Laughton's survey in 1874. Major Lees Smith, who had taken over charge from Colonel Macdonald, unfortunately succumbed to fever in 1882. He was an officer possessed of considerable mathematical talent, and his loss was much regretted. During 1882 and 1883 the scale of survey in the Thana collectorate was raised from two to four inches to meet the requirements of the Forest Department, and the country alternated between difficult mountainous jungle-covered districts and flat and marshy tracts along the seacoast, both of which proved very unhealthy to the party. The portions of the Konkan allotted to the party were completed in 1885, and a commencement was made of the topographical survey of the Southern Maratha country, the object being to undertake a topographical 2-inch survey of Bombay territory south of the parallel of 16° N.

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* *See* Appendix, p. 10.

atitude, together with a skeleton traverse survey of the forests, to serve as a basis for the construction of working plans by forest officers. The chief place of importance falling within the season's work was Belgaum, with its cantonment and fort. During the ensuing years the work was carried on by two separate sections, but in 1887-88 the Bombay Government represented that the skeleton boundary maps gave very meagre results compared with their cost, so after a conference at Poona between the Secretary to the Government of India, the Chief Secretary to the Government of Bombay, the Surveyor-General, and officers of the Forest and Survey Departments, the procedure was altered, and one entire party for forest topography was formed out of the forest sections of Nos. 10 and 17 parties, while the second party was to be employed exclusively on general topography.*

Assam and Sikkim.—In Assam a small party under Mr. W. H. Patterson had been deputed in 1877 to ascertain the areas of plots of land held by the *lakhirajdars*† preparatory to adjusting their claims and allotting what they were actually entitled to. The work consisting of three stages, viz., (1) the professional survey of interior details, (2) the adjustment of areas and boundary, and (3) the final demarcation and boundary survey, was carried on until 1878-79, but in that year the operations, so far as the Indian Survey Department was concerned, were brought to a close, as it was considered that the mere calculation of the areas could be effectually done by ordinary *amins* under the Settlement Commissioner.

On completion of Lieut. Harman's work in 1877-78 in Northern Assam, that officer's party was transferred to the Darjeeling district for the purpose of completing certain miscellaneous surveys required by the Bengal Government, the most prominent of which were a large scale survey of Darjeeling station and a survey of the route leading into Tibet from Rhenok to the Jelep-la pass. In October 1879 Lieutenant Harman started for Northern Sikkim and Mr. Robert for Western Sikkim to undertake a geographical survey of that State‡, while the remaining surveyors, European and Native, were left to complete the field work in the Darjeeling district. The result, however, was unfortunate in various respects, for Lieutenant Harman was badly frostbitten in his feet, and the surveyors at Darjeeling were called upon to perform a variety of pressing duties in the

* *See* page 90.

† Holders of land rent free.

‡ *See* footnote on following page.

neighbourhood as soon as their presence became known to the local officers and tea-planters. This comprised a large amount of survey work in the station of Darjeeling, in the Hope Town estates, and Government Khas lands, in the lands east of the Teesta river required for tea cultivation, and other places. The blocks of land newly taken up for chinchona cultivation in Sittong were also surveyed.

For the survey of Sikkim Lieutenant Harman undertook in person the whole of the country lying east of the range running south-east from Kanchanjanga, assigning the country to the west to Mr. Robert. He proceeded in the first instance to the snowy ranges on the frontier between Sikkim and Tibet, hoping to survey them during the brief interval between the cessation of the rains and the setting in of the winter with its heavy snowfalls. On ascending the Donkia-la pass, on the boundary, his feet were badly frostbitten, and he eventually lost four and a half of his toes, but with great persistence and energy he bravely continued his work, going about as best he could on coolies' backs, ponies, or crutches. He also visited the Kangra Lama pass, which lies north-west of the Donkia-la, and penetrated into parts of Sikkim which no European had previously explored. He was in Sikkim about three and a half months, during which he surveyed an area of over 1,000 square miles on the $\frac{1}{4}$-inch scale. Mr. Robert succeeded in surveying about 600 square miles on the same scale in Western Sikkim, including the boundary with Nepal. From the numerous commanding points on this mountain frontier he could see most of that part of Nepal which lies east of the southern spurs of Mount Everest, and sketched an area of about 900 square miles there besides fixing a large number of points on the surrounding hill ranges and in Sikkim. Mr. Robert's work was found to combine very well with that of Dr. Hooker.*

Lieut. Harman was an officer of immense enterprise and energy and untiring self-devotion; he greatly overtaxed himself in his arduous work, and at last his health broke down, and he had to retire from the service. He lived to join his family in Italy, but died soon afterwards.

* The survey of Sikkim was not sanctioned without a good deal of preliminary discussion, the then Lieutenant-Governor of Bengal being at first opposed to the undertaking. The papers on the subject contain some interesting information regarding Sikkim and Tibet, especially in connexion with Mr. Ware Edgar's researches. *See* Proceedings of the Government of India (Surveys), September 1879. It is needless almost to say that the survey subsequently proved of the greatest importance and use at the time of the Sikkim *imbroglio* with Tibet.

VI.

GEOGRAPHICAL SURVEYS AND EXPLORATIONS.

There is no department of the Indian Surveys in which more progress has been made during the last fifteen years than in the exploration and gradual opening up of the regions adjoining the periphery of British India. The admirable plan of training natives for surveying wild and unsettled countries, where a British officer would have but little chance of escaping molestation, has been greatly developed and crowned with the most complete success, while the hostilities in which we have unfortunately been involved with Afghanistan, Burma, and other powers have nevertheless been accompanied with a great development in our topographical, scientific, and general knowledge of these important countries. Finally, our political negotiations with Russia over the question of the northern frontier of Afghanistan, have resulted in a substantial enlargement of our stores of information respecting that region. Although a complete account of the Afghan Boundary Commission, and the multifarious inquiries and researches pursued in connexion therewith, has yet to be written, nevertheless, a great many scattered reports, scientific papers, and other contributions to the literature of the day have been published by the officers who took part in it. The summary of results given in the following pages will show that the information amassed by the British and Native members of the Commission probably ranks as the most important data ever collected respecting the Indian trans-frontier regions.

The extension of our geographical knowledge of Afghanistan, and the rectification of the hurried surveys which had been made during the first Afghan war but had never been properly combined together, had long been desiderata of great importance. So long, however, as it was considered the safest and best policy to prevent any attempt being made to survey beyond the British frontier, in order to avoid risk of collision with the independent tribes beyond, it was impossible for the survey officers to do more than fix all the most prominent points on the hill ranges beyond, which were visible from within the frontier, and to fill up the details of the country from native information or by the secret agency of native explorers.

But on the declaration of war with the Amir in 1878 it became necessary to attach surveyors to each of the four columns invading Afghanistan. To review, however, their geographical operations, it is more convenient to divide them into three groups, viz., 1st, those in Southern Afghanistan with the columns under the command of Generals Stewart and Biddulph; 2nd, those in the Kuram valley and generally to the south of the Safed-Koh range with the column under General Roberts; and 3rd, those in the Kabul valley and to the north of the Safed-Koh range with the column under General Browne.

Seven officers proceeded to rendezvous at Quetta, and much survey work was forthwith set on foot, the more important being Captain Beavan's route survey from Kandahar to Girishk on the Helmand river, and Captain Rogers's route survey from Kandahar to Kalat-i-Gilzai and back by the Arghandab valley. In March 1879 Captains Heaviside and Holdich accompanied the column under General Biddulph, which was under orders to return to India by the direct and hitherto unexplored route by the villages of Tal and Chotiali. The rapidity of the marches made it impossible to carry a continuous triangulation across the whole breadth of country, thus, after a while, Captain Holdich had to depend on his plane-table alone, but the final connexion with the fixed points of the Indus Series showed that the work was very accurate for a $\frac{1}{4}$-inch survey. It embraced altogether about 5,000 square miles. Lieutenant Gore carried out a survey of the Pishin valley, and Major Campbell, who was the senior survey officer in Southern Afghanistan, made a survey through the Shorawak valley (between Pishin and the great western desert) closing on Quetta. He also surveyed the Toba plateau, and his report thereon was printed for the Quartermaster-General's Department.

Captain Woodthorpe was attached to the Kuram valley column under General F. Roberts, and for four months was the only Survey Department officer serving with it. In March 1879 he was joined by Captain Gerald Martin. Woodthorpe accompanied the first advance of General Roberts's force to the Paiwar pass in November 1878, and took part in the fighting on the 28th November and 2nd and 3rd December. He had a marvellously narrow escape during the action of the 2nd, as in the dusk of the morning he went up by mistake to a breastwork occupied by the enemy, who did not discover his presence till he was within six yards, when they fired a volley at him. The stock of his pistol was smashed by a bullet which grazed

his side and drove a piece of his clothes into his sketch book, which was considerably damaged, but he himself escaped unhurt. He completed a reconnaissance up to the Shutargardan pass, the position of which proved to be considerably in error on the old maps, and returned through the Mangal country to Kuram. In January he accompanied the expedition into the Khost valley, and nearly the whole of Khost was mapped; subsequently ascents were made of various prominent peaks, including Sikaram, the highest point of the Safed-Koh range, and from that commanding position a good deal of topography was sketched in.

To the Peshawar or northern column, Major Tanner, Captain Samuells, and Mr. Scott were attached, Captains Leach and Strahan joining subsequently. Each of the first three officers took part in the advance on the fort of Ali Musjid, Captain Samuells distinguishing himself by carrying on his plane-tabling under a heavy fire; unhappily he caught typhoid fever and died soon after at Peshawar.* Major Tanner carried a continuous survey from Ali Musjid to Jalalabad, which was found to be about five miles nearer to Peshawar than previously accepted.

In May Major Tanner attempted an exploring trip into Kafiristan through the Kunar valley, and after several perilous adventures succeeded in reaching Aret in the Chugani or Kohistan country, which is on the southern confines of Kafiristan. Overcome with fatigue and exposure and prostrated with fever he was compelled to abandon his design and return to Jalalabad. An interesting account of his journey was read before the Royal Geographical Society.† Captain Leach joined the force in January, and during the two months he was at work surveyed a good portion of the Bazar valley and the country round Jalalabad, chiefly in the Shinwari country and on the northern slopes of the Safed-Koh range. At the end of March he was compelled to withdraw, in consequence of a severe wound received during an attack on his party by Shinwaris; his gallantry on that occasion won him the honoured distinction of the Victoria Cross. His place was supplied by Captain Charles Strahan, who with Mr. Scott did good work along the country south of the Kabul river. North of the Khaibar pass Mr. Scott happened to be attacked while surveying by a considerable number of Momands, and with difficulty made good his retreat to Fort Michni with a loss of one corporal and one Sepoy killed and wounded. The

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* *See also* Revenue Surveys, chapter, p. 124.

† On April 11th, 1881. *See* page 278 of *Proceedings*, R. G. S.

fight, a hand-to-hand affair, lasted the whole afternoon, and the safety of the party was due to Mr. Scott's gallantry.* Later on Mr. Scott visited the peak Sekh-ram (Sikaram), the highest point of the Safed-Koh range, where he obtained observations to numerous distant peaks, including a lofty pyramidical-shaped peak away to the north overtopping all the surrounding peaks of the Hindu Kush. The further identification of this important peak is a task reserved for some future traveller.

While Captain Strahan was surveying near Jugdulluk pass, where the remnants of the Cabul division made their last desperate stand in January 1842, he found that his assistant, Akram Khan, was the son of the man in whose house Captain Souter (father of Sir F. Souter of Bombay) had been detained as prisoner. Akram Khan remembered "Souter Sahib" and his teaching him a few English words, and produced a touching letter written by Captain Souter to Captain Fenwick at Jalalabad, bearing a postcript in pencil:—"I write this "as I believe it to be Sunday the 30th January 1842. * * * * "I have neither seen nor have been able to hold any intercourse "with Major Griffiths since the first day I arrived, now nearly three "weeks—a long time to wear a bloody shirt." Captain Souter and Major Griffiths were eventually taken with the other prisoners into Lughman by Akbar Khan.

The work completed by the surveyors attached to the northern column covered altogether an area of about 2,200 square miles, extending from Forts Michni and Jamrud on the British frontier near Peshawar to the Surkhab river west of Gundamak, and including a little of the northern and most of the southern portion of the basin of the Kabul river. Some blanks remained on the northern slopes of the Safed-Koh in the country of the Shinwaris and Khugianis, which were unavoidable owing to the conditions under which the survey in an enemy's country was conducted. A good deal of information was also obtained across the Kabul river in the Lughman plain and neighbouring tracts.

With respect to the lessons of the campaign, so far as survey matters were concerned, one of the most difficult proved to be the question of equipment and men. In a few instances it was possible

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* Mr. Scott received a sword of honour and an honorarium from the Government of the Punjab for his services in 1868. He also received an honorarium for the exploit described above.

to send men from headquarters fully equipped, but where officers were summoned from England or distant parts of India this was not possible, and some dissatisfaction was expressed, though the results showed that much excellent work was done by officers who raced up to the front as fast as they could, picking up men and instruments, camp equipage, and horses wherever they could find them on the road, and depending on border natives and even Afghans to fill up the personnel of the party.

The usefulness of the plane-table for military route surveys during the advance of the troops was fully proved. It is light, portable, and enables the ground to be mapped on the spot. If a good plane-tabler be given a base to start from of which the length and azimuth are known, with a fair proportion of commanding positions end hill peaks susceptible of ready identification, he can survey with great rapidity as he goes along and to a distance much beyond the positions which he may have reached. When, on the other hand, the troops march very rapidly and the route lies through a plain or else a country with hills which are inaccessible, the plane-table is at a disadvantage compared with a theodolite. In all rapid surveys occasional checks in the shape of astronomical observations for latitude and azimuth and longitude observations as well are desirable. For this occasion several officers in Afghanistan were supplied with a 6-inch transit theodolite, an instrument with a complete vertical circle and an eye-piece fitted with a pair of "sub-tense micrometers," which are intended to measure small angles subtended by distant objects in the field of the telescope. It is described in General Thuillier's "Manual of Survey for India" (3rd edition, page 132), also in "Hints to Travellers" by the Royal Geographical Society (4th edition, page 33). It may be called a universal instrument, for it is not only well fitted for astronomical observations as well as the ordinary measurement of horizontal angles, but it enables the distances of objects of known length to be determined very readily with the aid of the sub-tense micrometers, thus permitting measuring chains to be dispensed with in running traverses and measuring base-lines. It weighs 31 lbs. when packed in its box, the stand weighing 10 lbs. more, and is, probably, the lightest instrument yet constructed capable of such universal application.

On the conclusion of the Treaty of Gandamuk the surveyors were engaged at Mussoorie, bringing up their calculations and completing their maps, when the sad intelligence arrived in September 1879 of the massacre of Sir Louis Cavagnari and the members of the British

Embassy at Kabul. An immediate advance was ordered, and two survey parties were organized, one under Major Woodthorpe to proceed under General Sir F. Roberts, the other under Captain Holdich to join the column under General Bright viâ Peshawar and Jalalabad. Eventually both parties met at Kabul, where they made the most of every opportunity of acquiring a geographical knowledge of the adjoining country, and in continuation of the preceding surveys operated westwards and southwards up to the Pughman range and over almost all the country which is drained by the Logar, Shiniz, and other affluents of the Kabul river. In Southern Afghanistan some additional geography was obtained between Kandahar and Girishk and along the valleys to the west and north-west of Kandahar. A connexion with the operations in Northern Afghanistan was also made by the survey of the route from Kandahar to Ghazni through the Khushk-i-rud, Tarnak, and Ghazni valleys. In Baluchistan a rough reconnaissance was made of a considerable portion of the country north of Sibi inhabited by the Marri tribes, and detailed surveys were commenced in the plains around Sibi and Dadur.

The party under Major Woodthorpe reached Ali-Khel on the 4th October, a few days after the force under General Sir F. Roberts had advanced on Kabul. It was not till the end of the month that they proceeded on to that city, an interval which enabled Major Woodthorpe to connect the triangulation of the Kuram valley with that of the Logar and Kabul valleys, and thus establish the continuity of the series from Thull round by way of Kabul to Jalalabad. Mr. Ogle, of Major Woodthorpe's party, was detained in the Kuram valley, and accompanied General Tytler's column into the Zaimukht country, west of Kohat, where he secured topography to the extent of 880 square miles in country which was very little known, after which he joined the rest of the party at Kabul, where Captain T. H. Holdich, R.E., as the senior departmental officer, had assumed charge of the operations in Northern Afghanistan.

On the occupation of Kabul and partial investment of Sherpur by Mahomed Jan's forces in December, the officers of the survey had to help in the construction of defensive works, but after the defeat of Mahomed Jan Captain Holdich and Major Woodthorpe accompanied a brigade to the Koh Daman and mapped a portion of the country on the $\frac{1}{4}$-inch scale and established two trigonometrical stations there. The former then joined General Bright's division in the Lughman valley, between Kabul and Jellalabad, on the north side of

the river; on this tract some interesting notes were collected by Captain Holdich. It is on the summit of the great white peak of Kund overlooking Lughman from the region of Kafiristan that Noah's Ark is said to have rested after the Flood, and the valley of Dara-i-Nur, which lies on the border of Kafiristan territory, still bears his name. The famous ziarat or shrine of Lamech (Michtar Lam) is in the adjoining Alishang valley, and numbers of pilgrims annually repair thither from Jalalabad. There are evidences of a former Buddhist population in the caves bordering the river, both at Deronta and elsewhere. The Lughmanis too have ever been the connecting link between Kafiristan and the southern world in the matter of trade, and Kafir slave girls brought down from the mountains to the Dara-i-Nur were introduced by Lughmanis through the markets at Jalalabad and Kabul to the harems of the wealthy.

Captain Holdich then accompanied General Sir F. Roberts on his march through the Logar valley, taking advantage of the opportunity to make a leisurely re-survey of the valley on the $\frac{1}{2}$-inch scale. The valley is described by Captain Holdich as very beautiful at times, the white-walled, square-towered villages, each with its bastioned fort, being literally buried in groves of dark green mulberries and palm trees. Poplar avenues and wide fields knee-deep in clover or waving with wheat and fenced off with low mud walls or hedges of the wild yellow rose, form a pleasant contrast to the rough background of hills. Near the junction of the Logar and Kabul rivers there are Buddhist remains in plenty, one minar conspicuously erected on the ridge overlooking the Kabul and Khurd Kabul plains being 95 feet high and 62 feet in girth at the base. The Logar valley triangulation was at the same time improved and extended by Major Woodthorpe, who also fixed a number of points on the Altimor, Pughman, Deh-i-Sabz, and Karkatcha ranges. The same officer subsequently accompanied General Ross's division on its march towards Ghazni to meet Sir Donald Stewart advancing from Kandahar, and having extended the triangulation towards the head of the Logar river, effected a junction at Saidabad with the work of Lieutenant St. G. C. Gore, who had left Kandahar on the 30th March.

Amongst other surveys executed in Northern Afghanistan during the year should be mentioned Captain Martin's mapping of 700 square miles in the Koh-i-Daman and Kohistan, in the course of which he obtained information regarding the course of some of the

rivers issuing from the Hindu Kush and flowing down through the Kabul valley. Mr. Claudius completed the topography of the country from Gundamuk to Kabul on the ½-inch scale, and under the escort and guidance of a friendly Khan of Tezin he mapped an important bit of country which borders the route across the Lataband and Haft-Kotal passes. This part of his work was executed at considerable personal risk, and he was badly frost-bitten in carrying it through. Mr. W. W. McNair (who subsequently gained much credit for his adventurous journey into Kafiristan) completed the survey of portions of the Asphan and Hisarak valleys west of Gundamuk and the Lughman valley, both on the 1-inch scale, and later on he executed a large amount of excellent topography in the Logar valley on the ½-inch scale. The native sub-surveyors were found particularly useful throughout the campaign from the fact of their being able to move about the country without personal risk, even in disturbed tracts; their services were also largely utilised in pushing forward the military survey of the country round Sherpur and Kabul on the 4-inch scale. The "Munshi" particularly distinguished himself by mapping the Sherpur cantonments and the adjacent country during the actual siege and immediately after it, and thus did most useful topographical work before any European could possibly be so employed. He also undertook an exploration by way of the Kunar river into Kafiristan, travelling as a native doctor; there was every reason to suppose he could have succeeded in reaching Kafiristan (for he was never suspected at any time) but for an unfortunate rise of the Safis and Dehgans, which took place most unexpectedly. Returning to Kabul he was next employed in mapping (which he accomplished most successfully) a part of the district adjoining Kabul stretching through the Chardeh plain to the district of Pughman, which had been entirely closed to European officers and appeared likely to remain a blank.

The total area mapped in Northern Afghanistan during the season was estimated at 10,300 square miles, or adding 880 square miles of the Zaimukht country, 11,180 square miles, of which 64 square miles were done on the 4-inch scale, 1,276 on the 1-inch, and the remainder on the ½-inch and ¼-inch scales in about equal proportions.

Southern Afghanistan.—The officers deputed for survey work in Southern Afghanistan were Captains Rogers, Beavan, Heaviside, Holdich, and Lieutenants Gore and Hobday. Route surveys were

carried from a trigonometrical station on the frontier near Kusmore along the Dera Bugti road, *viâ* the Bolan Pass, Quetta, and Kandahar to Girishk on the Helmand on the one side, and to Kalat-i-Ghilzai on the other. Captains Heaviside and Holdich were subsequently attached to General Biddulph's column, which was returning to India by what is often called the Tal-Chotiali route, an important and direct line of communication between Multan and the Pishin valley, by which it had been originally intended that the Multan column should enter Afghanistan. The reconnaissance was a very rapid one, the average rate of marching being 12 miles a day, but a fair survey on the $\frac{1}{4}$-inch scale was nevertheless secured, embracing about 5,000 square miles.*

On completion of the survey of Pishin, Lieutenant Gore proceeded to Kandahar, *viâ* the Barghana route, which had not been previously surveyed, and mapped that route as well as a good deal of the surrounding country about Kandahar, and along the banks of the Argandab and Dori rivers to their junction. He also extended the triangulation towards the important village of Girishk, where the road to Herat crosses the Helmand river. An examination of part of the Arghastan valley above its junction with the Lora was also made, and the fact was elicited from natives that the latter river takes the overflow drainage from Lake Ab-i-istadeh, and on such occasions becomes very salt.

In the spring of 1880 Lieutenant Gore set out with the 1st Brigade of Sir Donald Stewart's force to Kabul, and advanced up the Tarnak valley. In the valley of the Ghazni river the famous battle of Ahmed-Khel was fought, and here much inconvenience was experienced, from a surveyor's point of view, owing to the difficulty of obtaining guides. When the fighting commenced, Lieutenant Gore's Hazara guide was with difficulty restrained from making off to get his share of the plunder. At last a richly-caparisoned horse trotting past proved too much for his cupidity and he finally decamped. Up to Shahjui, in lat. 32° 31′, Lieutenant Gore's work was based on trigonometrically fixed points, but beyond he had to rely on plane-table fixings and traversing until he joined Major Woodthorpe's work in the Wardak valley above Ghazni.

Major Leach, who had been invalided to Europe in consequence of a wound in the first campaign, was sent to Kandahar on his return, and executed some useful reconnaissances in the Argandab

* A picturesque description of the country was given by General Sir M. A. Biddulph before the Royal Geographical Society on the 9th February 1880. The paper in the Proceedings (p. 212) is illustrated with numerous sketches of the country.

and Khakrez valleys, and obtained valuable information concerning the passes into and across the Hazara country. Unfortunately the whole of this material, together with some important notes on the Hazara tribes, was lost during the retreat from Maiwand, and during the subsequent evacuation of the Kandahar cantonment. But Lieutenant the Hon. M. G. Talbot, R.E, and Lieutenant F. B. Long, R.E., replaced the survey portion by a subsequent exploration of theirs, and Major Leach drew up, mainly from recollection, a *resumé* of the lost notes,* and a sketch map of a country which had been up to that time a perfect blank. Major Leach accompanied General Burrows's force to Girishk on the Helmand, and did good service on the staff during the disastrous battle of Maiwand and retreat to Kandahar. He was then appointed Brigade Major of Engineers, and served in that capacity throughout the defence of Kandahar and in the subsequent battle of Kandahar, when the enemy, under Ayub Khan, were defeated by Sir F. Roberts. Lieutenants Talbot and Long accompanied the General in his memorable march from Kabul to Kandahar, and were also present at the battle of Kandahar.

During the following year a committee was formed at Kabul, under the orders of Sir Donald Stewart, for the purpose of considering the equipment necessary for a survey party in the field. The committee consisted of Lieutenant-Colonel Stewart, of the Guide Corps, as president, and Major Woodthorpe and Captain Holdich, of the Survey Department, as members. Their recommendations were as follows:—

1. A survey party should consist of one officer (who should be both accustomed to triangulate and to use the plane-table) and of two assistants (one of whom should be competent to triangulate) as topographers for each column operating on an independent line in a country where no survey has hitherto been made.

The native establishment for a party of this size should be as follows:—

For 1 officer 7 followers }
„ 2 officers 10 „ } inclusive of interpreters and permanent guides.

The addition of native sub-surveyors must depend entirely on the nature of the country under survey, but when they are employed, extra public followers, at the rate of at least one per sub-surveyor, will be necessary.

2. The instruments for the equipment of such a party will be as follows:—

1 six-inch subtense theodolite with full vertical circle and tripod stand.

5 plane-tables, viz., one for the officer in charge and two for each assistant.

The two for each assistant should be interchangeable on one stand and should be of different sizes and portability. The committee are of opinion that the plain deal table, 30″ × 26″, has, on the whole, been found to be of the greatest use on account of its

* Will be found in the Survey Proceedings of the Government of India for February 1882. It forms an interesting description of the Hazara country and people.

superior size and stability. It can be slung with its stand on a mule or pony without difficulty and can be used with cavalry. But each assistant should also be provided with a lighter, smaller, and more portable table, which can be conveniently slung on a man's back; a really portable table of this sort has yet to be devised, as also the best kind of stand.

Each officer or assistant should also be provided with the following minor instruments and books, viz.:—

Two trough needles, 1 sight-rule, 1 telescope or binocular, 1 aneroid barometer, 1 prismatic compass and stand, 3 thermometers for determining the boiling point of water, ordinary air thermometer, 1 Gunter scale, 1 beam compass, 1 small box instruments, 1 Shortrede's log tables, 1 Chambers's log tables, 1 auxiliary tables for facilitating the computations of the Great Trigonometrical Survey.

The officer in charge should carry in addition—

One Abney's level, 1 set scales, 1 maximum and minimum thermometer, 1 nautical almanac, 1 prismatic subtense instrument, 1 parallel ruler, 1 pantagraph, 1 manual of surveying, 2 sets measuring tapes (steel), 1 perambulator, lamps for observing, 1–6″ heliotrope, 1 chronometer watch, 1 portable sun-dial, spare compass and drawing pens.

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5. In addition to the usual personal baggage scale, the following will be required for the headquarters camp—

Office tent - - - -	150 lbs.
„ table - - - -	20 „
Stationery and small instruments -	160 „
Maps and data - - -	50 „

For public followers 1 sepoy's pâl, holding 17 persons, or its equivalent in smaller tents.

These recommendations were made on the following assumptions regarding the nature and extent of the work to be undertaken by the survey officers :—

A.—That a large extent of country, embracing several thousand square miles, may be either actually visited or sketched from a distance, during the course of a campaign.

B.—That every surveyor should be equipped to act independently, if necessary.

C.—That there may be no opportunities of visiting any portion of the ground twice, and therefore that all surveying must be done *pari passu* with the more or less rapid movements of troops along the main lines of communication.

D.—That maps are to be compiled and traced in the field, so that all the work of the survey can be put into the hands of the generals concerned as speedily as possible.

E.—That the topographical operations are not to consist merely of surveys of the lines of route, but are to embrace as much as possible of the surrounding country, and must therefore be executed on a trigonometrical basis; consequently, that the surveyors must always work together in pairs, one doing the triangulation, the other the topographical sketching; for, when the troops are marching rapidly, it is impossible for any single man to do both, and each is required to supplement the other.

F.—That the survey office with the army will be the general depôt for all maps of the country which may be published by the Surveyor-General's Department and be supplied for distribution as required.

G.—That the sanctioned allowance of baggage and equipment for every officer in the field who is employed in transport, commissariat, or any other duties which oblige him

to carry his own camp equipage and make it impossible for him to join a mess, is 400 lbs.

The above recommendations were influenced by the protracted military occupation of Afghanistan; much valuable work in the way of military survey and reconnaissance may of course be done by officers equipped more lightly with fewer and smaller instruments; indeed in rapid marches through an enemy's country it would be necessary to restrict the equipment of each survey officer to what he and one or two attendants could carry. Much depends on the character of the surveying to be done: the geographical and smaller scale survey being more valuable for rapid strategical movements over a large area of country, while the topographical survey of the military roads and lines of communication, and of the ground in the immediate neighbourhood, is usually to aid a general officer in determining the best disposition of his troops in action or wherever liable to be attacked by an enemy.

In the first Afghan war a large amount of route surveying was executed, mostly on the scale of one inch to one mile, and some was of very good quality, but few, if any, attempts were made to carry on a general geographical survey of the country *pari passu* with the military route surveys. Thus when the latter came to be combined together, large gaps were found to exist, and even what had been done could not be accurately combined, the result being that Kabul and Kandahar were shown on the maps as 7 and 15 miles west of their true positions.

In the next Afghan war (1878–79) the survey officers were directed to obtain as much information as possible respecting the country at large, and not merely to operate on the military lines of communication. For this they were directed more especially to make general maps of the country on scales of half an inch or quarter of an inch to the mile, by plane-tabling on a trigonometrical basis, also to carry route surveys on the 1-inch scale with the most suitable instruments available over the principal routes traversed by the troops. It was arranged that larger scale work should be done by some of the numerous field engineers and staff officers attached to the army. Such were the general lines and general division of labour laid down for the Afghan campaign, and the system was found to work well.

From the invasion of Afghanistan in 1878 the area surveyed in more or less detail by the officers of the Department amounted to 39,500 square miles, while a further area of 7,000 square miles was

explored by native agency. In Baluchistan an area of about 7,800 square miles was surveyed.

One of the broad results was to show that the positions of Kabul, Ghazni, and Kandahar as determined during the first Afghan war were correct in latitude but erroneous in longitude as mentioned above. A large number of heights also entered on the old maps turned out to be considerably in excess of their true values. They appear to have been mainly derived from barometric observations taken by Dr. William Griffiths, who was a skilful and accurate observer, but who unfortunately did not live to reduce his own observations. The method of reduction adopted did not take account of the well-known hourly, daily, and monthly variations of barometric pressure, a neglect which is liable to affect the results very materially. Thus while certain height determinations proved to be very satisfactory, others, particularly those in the high lands around Ghazni and Kabul, were found to be materially erroneous, thus :—

Positions.	As since determined.	As deduced from Dr. Griffiths's Observations.
Quetta	5,515	5,537
Kandahar	3,400	3,484
Mukur, latitude 32° 51′, longitude 67° 47′	6,561	7,091
Obeh, latitude 33° 0′, longitude 67° 56′	6,986	7,325
Ghazni	7,279	7,726
Shashgao, latitude 33° 45′, longitude 68° 32′	8,184	8,697
Shekhabad, latitude 34° 1′, longitude 68° 45′	6,884	7,473
Kabul	5,780	6,395
Butkak, east of Kabul	5,980	6,248
Khurd Kabul	7,500	7,466
Gandamak	4,500	4,616
Jalalabad	1,950	1,964
Peshawar	1,135	1,068

North-west frontier and adjacent regions.—During the year 1876 one of the trained native explorers of the Great Trigonometrical

survey, named "the Mullah," ascended the Indus river from the point where it enters the plains of the Punjab at Attock to the point where it is joined by the Gilgit river. Other portions, of course, of the Indus from the table lands of Tibet, where it takes its rise, down to the ocean had long since been surveyed, but the part referred to had been always shown by a dotted line on the maps. The great river here traverses a tract about 220 miles in length, descending from a height of about 5,000 to 1,200 feet above sea-level. It flows tortuously, in a deep narrow-cut gorge, through great mountain ranges with peaks rising from 15,000 to 26,000 feet in height. The positions and heights of all the most commanding peaks had been fixed by Captain Carter's triangulation, but no European had penetrated into the region. Very difficult of access from all quarters it is inhabited by a number of hill tribes, each living independently in secluded valleys, and suspicious of its neighbours. Each community elects its own ruler, and communicates with the outer world only through the medium of a few privileged traders. The Mullah happened to possess the privilege and was thus enabled to explore the Indus and some of the lateral valleys. This work done, he proceeded in accordance with his instructions to Yassin, marching through the Gilgit valley but not surveying it, as the late Mr. Hayward (who was there murdered) had furnished a good map of those parts. From Yasin he surveyed the southern road to Mastuj, through the Ghizar and Sar Laspur valleys, supplying an important rectification of the topography. At Mastuj he struck upon his old route from Jalalabad over the Hindu Kush to Wakhan in 1873, and proceeded in a north-easterly direction back to Yasin, crossing the Tui or Moshabar pass, which is conjectured to be 16,000 feet in height. On his return journey he again passed through Sar Laspur, explored the Tal pass, and traversed the length of the Panjkora valley, the whole journey having added much to our knowledge of the Trans-Indus frontier regions.

During the course of his travels in 1876 the Mullah had acquired much information respecting the regions surrounding the Swat valley; the exploration of the valley itself was undertaken in 1878, and to facilitate matters and disarm the suspicion of his being in Government employ, which had arisen during the former journey, the Mullah placed himself in communication with a trader from Swat and assumed the part of a timber merchant anxious to make purchases at Lamuti and Kandia, whence large quantities are annually floated down to Peshawar and Attock. The Mullah entered the

Swat valley near its junction with the Panjkora, and then proceeded up the former valley, making excursions up the principal lateral glens on the right bank, until he reached Kolam in the Kohistan, in which the sources of the river are situated. He then surveyed the route leading over the water-shed into the Panjkora valley at Lamuti, in order to connect his fresh explorations with the previous ones, after which he returned to Kolam and ascended the Swat river until he approached the water-parting of the range running east and west, and separating the waters of the Gilgit river from the streams to the south. He then crossed the Palesar pass into the Kandia valley, one of the tributaries of the Indus, and worked down to the latter river, where he joined on to his previous route, and turned southwards, along a route running parallel with the Indus river, but several miles to the west, crossing the whole of the lateral valleys on the right bank of that river and acquiring much supplementary information to add to his original survey. Finally he crossed over the range to the right and closed his work on to the line of his survey up the Swat valley. The journey was encompassed with many hardships, and, lying through a country to which Europeans have never penetrated, it was one of considerable interest. The northernmost point reached was the Palesar pass across the great water-shed separating the Yasin and Gilgit countries from Bashkar, Darel, and Tangir, near to a point where the range turns to the southward. It rises abruptly in great scarps from the very banks of the Indus at Bunji, in the east, with an average height of from 16,000 to 19,000 feet as it approaches the Kunar valley. This range is a very important geographical feature, for it separates the rainless tracts of Gilgit, Hunza, and Yasin to the north from the well-watered countries of Bashkar, Swat, &c. to the south. To the north the vegetation is limited to a narrow belt of pines, cypresses, and birch, while to the south the forests are described as magnificent with a profusion of deodar. In another particular this mountain range has an importance, for it forms broadly a great boundary line between the adherents of the Shiah and Sunni religions.

The general route-survey work accomplished by the Mullah fits in fairly well with the peaks previously fixed by triangulation, and the detailed narrative is a genuine story, told with touching simplicity, of perils and privations faced and patiently surmounted.

In 1877 M—— S——, a native gentleman of the Muhammadan faith, and of much repute among his co-religionists, was about to make a journey from Kashmir across the Hindu Kush mountains

and the Oxus river to Kolab in Badakshan, to visit the shrines of his ancestors and transact some business of his own, when he learned from one of his friends that he might obtain employment in geographical exploration in connexion with the Indian Survey Department if he would volunteer his services and go through a course of training. His services were readily accepted, as he was a man of considerable intelligence and good education, so having been put through a course of training under the veteran explorer Pundit Nain Sing, he started for his destination *viâ* Kashmir, Gilgit, and Yasin, where he arrived on the 14th December 1878. At the latter place he was detained on one excuse and another till September 1879, when he was permitted to depart and proceeded up the Darkot valley and over the Baroghil pass to Sarhad and Ishkashim. At this point it was his intention to have proceeded down the valley of the Panj or Oxus to Shignan and Darwaz, but owing to the feud between the rulers of these two States he was unable to reach Kolab by that road, and had to proceed *viâ* Faizabad. His route from thence coincided partly with that of the Havildar in 1874, but embraced a far larger area of new ground. He ascended the Doaba Dara, a tributary of the Yakhsu, to its source, and followed the great bend of the Upper Oxus or Ab-i-Panjah river to Varv, where the Havildar had been turned back, and where he too was stopped on the same plea, that of hostilities between the people of Darwaz and their neighbours in Shignan and Roshan. He then retraced his steps to the Dara Imam, and crossing the Panjah ascended the table-land of Shiva, a large expanse of country lying within the bend of the river, and till then wholly unknown. This took him right across the central regions of Badakshan, and enabled him to complete his survey of the upper course of the stream. M—— S—— also ascended the Bartang or Murghabi river to its source in the Sarez Pamir, a distance of 100 miles. On his return he was laid up for five months with rheumatism at Kila Bar Panjah, after which he proceeded to explore the Shakh Dara valley, with the intention of crossing into Wakhan over the intermediate ranges, but the passes were found to be blocked with sand and impracticable, consequently he retraced his steps and returned by way of the Ab-i-Panjah to Ishkashim. He diverged from the route he had followed on his outward journey to visit the Ghazkol lake, which lies at the point of convergence of the Muztagh and Hindu Kush ranges, and which some suppose to have a double outlet into the Ishkaman and Mastuj rivers, and having determined its position he closed

his work at the Darkot pass, having contributed enormously to the existing geographical knowledge of Badakshan. M—— S —— was presented with one of the two medals which were placed at the disposal of the Surveyor-General of India by the Venice International Geographical Congress for award to meritorious Native explorers.

At the time that the late Colonel Montgomerie and his assistants had been employed in surveying on the north-western confines of Kashmir, operations had not been extended across the Indus owing to the unfriendliness of the Gilgit people, but in 1878 matters were so improved that on his return from Southern Kafiristan Colonel H. C. B. Tanner was deputed thither with two native surveyors. His first task was to extend the regular survey over Gilgit and the vicinity, where he mapped an area of about 2,000 square miles on the ¼-inch scale. The great ridge referred to in the preceding paragraph proved to be most difficult to map, the central backbone being like a huge broken table-land running up into wave-like ridges, rising but a few hundred feet above the general level of the range, and practically impossible to distinguish apart. This, added to the inclemency of the season, snowstorms being exceptionally frequent, prevented many of the peaks being satisfactorily identified.

Colonel Tanner was returning to recess quarters to bring up his mapping and calculations of work done during the summer of 1880, and had reached Lahore when he was ordered back to Srinagar, and placed in command of a body of troops in the service of the Maharajah of Kashmir under instructions to proceed to Gilgit for the relief of Major Biddulph, the Political Officer stationed there, who was threatened by a general rising of the surrounding tribes. This prevented the completion of the mapping, but with the assistance of his native surveyor, Ahmed Ali Khan, he made a survey of an area of about 2,000 square miles, and extended the limits of the Gilgit map as far as Astor to the south-east, northwards to the great range separating little Guhjal from Gilgit, southwards to Chilas, and westwards to the mouth of the Wurshigum river at the entrance to the Yasin river. The positions of several distant peaks on the Hindu Kush range were fixed, among them the summit of the notable Tiraj (Tirich) Mir north of Chitral, first brought into prominence by Major Biddulph.* Its height as deduced by Colonel Tanner from his calculations is 26,425 feet above the sea.

* Major Biddulph is the author of an interesting work, "The tribes of the Hindoo Koosh," containing much valuable information accumulated by him during his sojourn in those regions.

Colonel Tanner's description* of the wilderness of mountains and peaks of every possible form by which he was surrounded is exceedingly graphic, and gives a good idea of the remarkable and lofty region in which he was working. He was very anxious to get a near view of the great mountain of Nangaparbat, near Astor, and after a most perilous passage over a narrow, rugged ridge surrounded by enormous precipices, which tried his nerves to the utmost, he found himself confronted by what is probably the most magnificent snow view on the globe, embracing as it does a slope of very nearly 24,000 feet (vertical measurement), with glaciers, snow-fields, ice-cliffs, and jagged needles of naked rock extending from the summit of this king of mountains down to the Indus, which flows in a deep channel at its base. Colonel Tanner says he is unable to convey an adequate description of the superb and impressive view which he contemplated from the edge of a tremendous precipice, whose summit is 16,000 feet above the sea, and which rises sheer and unbroken from the forests and vineyards of Gor, situated at an immense depth below.

During the season 1880–81 the survey of Gilgit was completed by the sub-surveyor Ahmed Ali Khan, who also continued the map of the Astor country towards the chief passes which lead into the Indus valley on the one hand, and those leading into Kashmir on the other. All the passes leading out of the Gilgit valley into Darel, Chilas, and the adjacent parts of the Indus basin were also mapped. His work during the following season (1881–82) lay about the Indus-Kishenganga watershed, and in 1882–83 he completed the survey of Chilas and fixed the position of the passes leading from the valley of the Indus into the Kaghan, Kishenganga, Astor, and Gilgit basins, as well as the positions of all villages and forts. His survey of Dardistan, as this region has been sometimes called, includes an area of about 2,000 square miles, mapped on the $\frac{1}{4}$-inch scale, an out-turn reflecting much credit on Ahmed Ali Khan, as on several occasions he had to pass the night without a tent, on ground buried in snow, at heights from 14,000 to 16,000 feet above the sea.† His survey of the upper part of the Kishenganga valley was completed in the following year (1883–4).

* Appendix to Surveyor-General's Report for 1879–80, p. 42.

† An account of Dardistan, the nature of the country, trees, produce, and cattle, the religion, customs, dress, arms, dwelling-places, and commerce, will be found at page xxiv. of the Indian Survey Report for 1883–84.

The withdrawal of the British forces from Afghanistan in September 1880 brought all surveying operations to a close in that part of the country. But in March 1881 the conduct of the Waziris, who inhabit the tracts adjoining the British districts of Bannu and Dera Ismail Khan, and have proved such unruly neighbours since our annexation of the Punjab, necessitated the despatch of a fresh expedition into their country, and this gave opportunity for additional survey work. One column under Brigadier-General Gordon advanced from Bannu up the Khaisar valley towards the Razmak valley along the northern part of the country, and returned through the Shikto valley to the plains of Bannu. The other column under Brigadier-General Kennedy advanced from Tonk into the southern and western Waziri valleys, and then proceeded *viâ* Kaniguram to the Razmak plateau, and returned *viâ* Palosin to Tonk. To the first column Major Holdich and Lieutenant the Hon. M. G. Talbot were attached as survey officers, and Captain G. W. Martin accompanied the second column. These three officers, aided by the native surveyor, Imam Baksh, who was taken under tribal protection into tracts closed to Europeans, surveyed an area of about 1,200 miles in and around Waziristan, and filled up blanks for portions of the country which had not been visited during Sir Neville Chamberlain's expedition in 1860, and which had never before been seen by Europeans. The plane-tabling by Lieutenant Talbot of the watershed between the Khaisar and the Dawar Dour formed a useful continuation of Colonel Woodthorpe's work in Khost with Sir F. Roberts's expedition. The survey officers were able to ascend several mountains on the western confines of the country, including the peaks of Pirghal and Shuidar 11,000 feet in height. Fortunately the atmosphere was generally clear, and points were fixed as far as 200 miles distant, which in spite of the hurried character of the movements of the troops combined to give good results. A valuable reconnaissance of the Zhob valley and the upper branches of the Gumal valley towards the Ab-i-istadeh lake was also made by a native explorer. His map covered an area of 7,140 square miles, and though a good deal of this was rough and only sketched in by the eye, it supplied some important corrections to the previous geographical knowledge of the country. Some interesting notes on the tribes and the roads were compiled from the explorer's information by Lieutenant Talbot.*

* *See* Appendix to Surveyor-General's Report for 1880–81, p. 36.

Generally speaking, the operations in Waziristan had an important bearing on the Kuram and Khost surveys, and formed a connecting link between the triangulation in northern and southern Afghanistan.

The survey arrangements with the Zhob valley expedition were originally placed in the hands of Major Holdich; but when he was suddenly called upon to join the Afghan Boundary Commission the charge devolved on Lieutenant R. A. Wahab, R.E., who had a short time previously accompanied Sir R. Sandeman into south-west Baluchistan and carried a series of triangles towards Panjgur. For the Zhob valley operations Mr. G. B. Scott and Sub-Surveyor Muhammad Yusuf Sharif were attached to Lieutenant Wahab's survey party. The operations lasted two months, during which about 400 square miles of country were surveyed or reconnoitred on the ½-inch scale, and from 5,000 to 6,000 square miles on the ¼-inch scale. The valley was surveyed in detail from its head to Mena, and the mountainous tract to the north as far as the watershed dividing it from the Kwandar valley was reconnoitred and sketched. Efforts were made to extend the triangulation into the Kwandar basin, but this was found impracticable. A large part of the Bori valley and the country separating it from the Tal valley was surveyed on the ½-inch scale, and parts of the Musa-Khel country and the Nalai and Mekhtar valleys.*

In November 1883 an expedition was organized to the Takht-i-Suliman mountain, west of the town of Dera Ismail Khan. The object of the survey expedition was to explore the Takht-i-Suliman mountain and complete as much of the topography as possible of the Sherani country, keeping up a continuous border survey with that already completed to the north, which terminated about the line of the Gumal valley, and to fix points to the west. These objects were generally secured, though the innumerable lines of hills traversing the central Afghan plateau were much dwarfed when seen from the lofty elevation of the Kaisarghar, and no peaks appeared specially prominent. Many important geographical features in the Birmal hills, the Gumal and Zhob valleys, and the Musakhel country of the

* Lieutenant Wahab's reports are contained in the Proceedings of the Government of India, Revenue and Agricultural Department (Surveys), March 1885, Nos. 19 and 20. The Zhob valley has since been mapped by Colonel Holdich.

Upper Vihowa (recently explored by the Hakim and the Bozdar) were easily identified, and the general correctness of the geography certified. Yusuf Sharif's survey of the Gumal pass connects the work with Waziristan on the north,* and a subsequent exploration of his filled in further details in continuation of the Bozdar's topography; so with the exception of the Dabua pass the topography of the country was continuous and complete from Kohat to the Reminuk pass.† The expedition had enabled the northern and highest peak of the Takht-i-Suliman group, Kaisarghar (11,300 feet above the sea), to be scaled, and much of the surrounding togography to be checked and amplified by Major Holdich and his assistants. The only opposition encountered was from some hot bloods of the Khiderzai clan, who by means of a flank movement were dispersed with but little trouble. In this manœuvre the British force was guided mainly by the local knowledge of Sub-Surveyor Imam Baksh, Bozdar, who also completed the largest share of the topography of the adjoining country.

This distinguished native officer during his 25 years' active service took part in eight different campaigns or expeditions, and besides the Takht-i-Suliman surveys rendered most useful service in surveys of the Zhob river, the Vihowa basin, and Musakhel country, and also in Gilgit and Hunza, under Colonel Tanner. He was given a grant of 250 acres of land in the Dera Ghazi Khan district, and in 1884, on his retirement, the title of "Khan Bahadur" was conferred on him by the Viceroy.

In the Jowaki hills a tract of country left unsurveyed during the military expedition of 1877–78 was mapped out by Yusuf Sharif, with great courage and tact, the neighbouring chiefs being particularly enraged at the open manner in which he used his plane-table, and in spite of musket shots insisted on completing the last bits of the survey so as to fix the position of Musadarra. Further to the west some useful work was done by Mr. Claudius, who disguised himself and relying on the protection of the Chiefs, without companions or servants of any kind, but equipped with a small plane-table, unscrewed and in pieces, advanced up the valley of the Bar

*Captain G. F. Young made some useful contributions to the knowledge of Waziristan in his Notes on the Shaktu Valley, which had been previously quite unknown. *See* Proceedings Royal Geographical Society, p. 537, of 1882.

† Appendix, p. xxxviii., Report of Surveyor-General of India for 1883–84.

Marai and ascended a lofty peak commanding the Urakzai Tirah. Fraternising with the people, he obtained all the opportunities he required, and retraced his steps across the border. He then set out on a second expedition up the Bizoti and Bara valleys, but his disguise was detected and he was turned back by armed tribes. The topography of the border was however extended as far south as Bannu. The tract extending to the Gumal valley was taken in hand by Mr. McNair, who sketched the valleys of the Kaitu Kuram, the Baran, the Tochi, and the Khaisar, the high lands of the Batanis, &c. This work was rendered especially trying by the orders given that surveyors were never to camp outside the border; thus men were often tired out with a long march before the day's work began. Behind this strip of frontier survey continuous maps were produced by native explorers working bit by bit on one half the scale of the other surveys. The "Hakim" brought in a reconnaissance of the Tochi valley and fixed the position of the Kotanni pass which leads into the Ghazni basin. The "Syud," a well-known explorer, traversed the direct route between Bannu and Ghazni, but at the latter place his disguise was detected, and he was seized and imprisoned, but eventually was sent to Kabul and taken before the Amir, who allowed him to return to British territory by the Khyber route. Unfortunately some of his original documents were lost, but he brought valuable information regarding the direct route from India to Ghazni. The veteran the "Bozdar" was not actively employed during the season 1882–83, but various opportunities enabled the accuracy of his work during the previous season, when he explored the affluents of the Gumal, the Sharan, and the Kandil rivers, to be confirmed.

In March 1883 Mr. McNair and the "Syud" started on a most adventurous journey into Kafiristan, the former assuming the dress and disguise of a *hakim* or native doctor, for which purpose he shaved his head and stained his face and hands and wore the dress peculiar to the Mians or Kaka Khels, a clan who possess influence throughout this part of Afghanistan and Badakshan. The party consisted of 40 people in all, including mulcteers, and 15 baggage animals, and among the goods a prismatic and magnetic compass, a boiling-point and aneroid thermometer, and a specially constructed plane-table were secretly stowed. The latter article was in constant use throughout and answered capitally, as in case of surprise the paper in use was slipped inside and the plane-table became a doctor's pre-

scription book. On one occasion while observing on the summit of the Laram Kotal, Mr. McNair was within an ace of being detected by the sudden appearance of four men armed with matchlocks, but in the twinkling of an eye the ruler or sight-vane was run up his long open sleeve, and the pretended doctor was absorbed in hunting for roots.

Crossing the Swat valley and passing through Dir the party advanced over the Lahori pass and up the Kunar valley to Chitral, where they waited with presents on the Badshah, Aman ul Mulk. Mr. McNair was allowed to go up and reconnoitre the Dora pass over the Hindu Kush; he says it is a little over 14,000 feet, the ascent is very gradual and quite feasible for laden animals, but owing to the people of Munjan and the Kafirs of the Bogosta valley, traders prefer the route viâ the more difficult Nuksan pass. Neither pass is open for more than three months in the year. Mr. McNair also made an excursion westward of Chitral, by way of Rumbur and Bamburath over the water-shed into the valley of the Arnawai river, where he was well received by the Ludhe* villagers. A report was however spread about by a rival Kakar Khel, Rahat Shah, that two Europeans had come disguised into the country, and the ruler of Chitral having sent for Mr. McNair, the latter was compelled to return and abandon all further attempts at exploration. He returned to Kashmir by way of Mastuj and Yasin, the route followed by Major Biddulph. A full account of this journey was given by Mr. McNair (who has since died) before the Royal Geographical Society,† and the following year the Society awarded him the Murchison grant for the same.‡

The depredations and unruliness of the tribes about the Black Mountain on the Hazara border necessitated the despatch of a punitive expedition in November and December 1888, which was accompanied by Captain R. A. Wahab, R.E., and two sub-surveyors, Imam Sharif, K.B., and Ata Mahomed Khan. The last-named surveyor, however, died at Kotkai, and the work consequently fell

* This is evidently the Lut-dih territory mentioned by Major Raverty, at page 149 (Section III.) of his "Notes on Afghanistan," &c. The pass leading into the valley of the Oxus is called Apaluk by Major Raverty, and is said by the major to be fairly easy, but I have never seen any other reference to it.

† On the 10th December 1883, *see* Proceedings R. G. S. for 1884.

‡ Kafiristan has since been visited from the Chitral side by Dr. Robertson and Mr. Kitchen, Assistant Surveyor, in 1889–90.

on Captain Wahab and Imam Sharif, who succeeded in mapping an area of 423 square miles on the ½-inch scale, including practically the whole course of the Indus to a point considerably above the great bend of the river near Thakot, and a good deal of ground across the Indus adjoining Buner. These operations combined with the results of the expeditions in 1852–53 and 1868,* and with the survey of the Mullah (*see* page 141) enabled a new sketch map of the Black Mountain district to be compiled on the 1-inch scale.

Tibet, Nepal, and Bhutan.—The country between Sikkim, Shigatze, and Chetang was traversed by the explorer L——, who started from Darjeeling in March 1875, with the intention of reaching the Tsanpo and making a route survey along as much of its course as was practicable. The direct route from Sikkim to Shigatze had not been previously surveyed, as it crosses a frontier line which is guarded with much jealousy by the Tibetans. Shortly after crossing the Kangralama La or Lachen pass he was taken prisoner and sent to Shigatze, where he was kept five months. He was then allowed to join a party of merchants and travelled eastwards to the Yamdok-tso lake, after which he turned northwards and followed the river to Chetang, but was warned that further progress along its banks was useless unless in company with a strong body of men to protect him from the robbers and wild tribes, so he turned southwards and tried to return to India by the route *viâ* Tawang taken by Pundit Nain Singh in 1874–75. The authorities at the latter place however, stopped his further progress and confined him in the public flour mill. Eventually he was enabled to return to Darjeeling *viâ* Giangtse Jong, Phari, and the Chumbi valley, which had been partially traversed by Captain Turner in 1783.

But the most remarkable of the journeys made by any of the Indian native explorers was that of A——k in Great Tibet in 1878–82, in the course of which he traversed the entire breadth of the Tibetan plateau from its origin in the Himalayas to where its northernmost spurs die away in the Mongolian deserts, and explored a large tract of unknown ground on the confines of South-Eastern Tibet and Western China.

A——k, whose real name is Krishna or Kishen Singh Milm-wal, is by caste a Rawat Rajput, and first cousin to the late Nain Singh, C.I.E., by whom he was trained. The family have been established for many generations in Milam in Kumaun, where they are held in

* *See* Paget's Record of Expeditions against the N.W. Frontier Tribes; revised by Lieutenant A. H. Mason. London (Whiting & Co.), 1884.

esteem and from whence they derive their designation of "Milm-wal." In 1812, when Milam was in Nepalese territory, Messrs. Moorcroft and Hearsey were travelling in Western Tibet disguised as fakirs, and under the assumed names of Mayapuri and Hargiri. They visited Hundes and Gartok, but on their return journey were taken prisoners and detained at Daba Jong, some 80 miles N.W. of the Mansarowar lake. Deb Singh and Ber Singh (father and uncle of Kishen Singh) hastened to proffer their good offices, a kindness which Moorcroft and Hearsey acknowledged in the following testimonial:—

"This certifies that Deb Singh and Ber Singh, sons of Dhamoo, an inhabitant and man of consequence in the town of Melim in the country of Jooar, have shown to us great attention and civility. Under an idea that we were in want of funds they offered us a hoondee on Sreenuggur for a thousand rupees, to be paid at whatever period might suit our convenience, and either in money or goods as might be most agreeable to us. Although the state of our finances rendered the loan unnecessary, we have much pleasure in recording the circumstance and in giving this testimonial of the goodwill they bore towards us.

Northern foot of the Himachal mountains, near Daba, in Chinese Tartary. 25th August 1812. (Signed) W. MOORCROFT.
" H. J. HEARSEY.

A second testimonial signed by Mr. Moorcroft alone, bearing the same date, recommends that the Honourable Company's officers will afford all due facilities to Deb Singh and Ber Singh in enabling them to dispose of their merchandise on the British side of the frontier. The release of Messrs. Moorcroft and Hearsey was eventually effected by the interposition and on the security of Deb Singh and Ber Singh, but the certificate from Moorcroft giving the particulars of the incident has unfortunately been lost. The other certificates are still in the possession of Kishen Singh.

Kishen Singh had made several successful explorations before undertaking his fourth journey, viz:—

(1.) 1869.—From Milam in Kumaun to Rakas Tal lake in Great Tibet and thence southward along the Karnali river to Kathai Ghat in British territory, 400 miles.

(2.) 1871-2.—From Shigatze to the Tengri Nur and thence to Lhasa, 300 miles.*

(3.) 1873-4.—From Tankse in Ladak to Kashgar and beyond, thence south-east to Polu and south to Noh in the Pangong and back to Tankse, 1,250 miles.†

On the occasion of his fourth and greatest journey Kishen Singh was accompanied by a Bodh fellow-villager called Chambel, who,

* Report of Great Trigonometrical Survey for 1873–74, Appendix 2.

† *See* page 442 of "Report of a Mission to Yarkund in 1873." Calcutta, 1875.

though not so highly educated as Kishen Singh, and a good deal older, displayed the most unswerving fidelity throughout their wanderings.

A——k and two companions left Darjeeling on the 24th April 1878, and proceeding as Captain Turner did in 1783 by way of the Jelep La pass and the Chumbi valley, he passed through Giangtse and the Yamdok-tso lake, which he described as shaped like a horseshoe. The Sanpo was crossed by the famous suspension bridge north of the lake, and on the 5th September 1878 the party arrived at Lhasa and replenished their merchandise. During his stay there A——k employed his time in learning the Mongolian language and in collecting a large amount of information regarding the city, the people, and their customs. It was not till the 17th September 1879 that A——k was enabled to join a caravan proceeding to Mongolia. The party consisted of 105 persons, 60 of whom were Mongolian of both sexes and the rest Tibetans, including A——k's party of six. Great care had to be exercised to avoid the roaming bands of armed and mounted robbers, sometimes 300 strong, which infest Northern Tibet, and this necessitated the adoption of a more westerly route than the regular line of march to Sining. At the Ma-chu river, one of the tributaries of the Upper Yangtse-kiang, a caravan proceeding to Lhasa was met, but it was subsequently turned back by snow, and A——k's party fell in with it again on descending from the Angirtakshia or Kuen Lun mountains† into the Naichi valley. The last part of the journey had proved very severe, and several of the beasts of burden had succumbed. The Naichi valley is several thousand feet lower, and is covered with rich pasturage, which affords sustenance to large herds of ponies, thick-tailed sheep, Bactrian camels and goats. It forms part of the Tsaidam depression, the drainage of which appears to have a general westerly flow, but no outlet into the Lob basin.* The Mongolian nomad inhabitants proved to be very hospitable, and they invited the members of the caravan to lodge with them. At Thingkali the caravan was attacked by 200 mounted robbers; a battle ensued, and after a somewhat desultory firing the robbers fell upon the party with swords and spears, so A——k and his friends fled with only their arms and instruments. At Hoiduthara the party were very kindly treated by a Tibetan of Giangtse, and remained with him three months. They then

* This I infer from the heights on the late General Prshevalsky's map.

† An exhaustive memoir, by Captain G. Kollm, on the Kuen Lun range will be found in the Zeitschrift of the Berlin Geographical Society (Band XXVI., 1891, No. 3).

turned to the north-west through the region traversed by General Prshevalsky in 1880. In some of the valleys adjoining the Saithang plain (between 38° and 39° N. latitude) wild men are said to exist (Prshevalsky mentions having seen one). A——k states that these men wear skins and live in caves and glens and under the shelter of overhanging rocks. They are ignorant even of the use of arms, and lie in wait for their prey near pools or springs of water, and are remarkably swift of foot. They kindle fire with flints and flay the animals they kill with sharp-edged stones. In this region wild camels and wild horses are also found.

At Yembi, in Saithang, the party remained three months, but here M——g, one of A——k's companions, treacherously deserted with 150 rupees in coin and five ponies, and this compelled A——k to take service for five months. Their next important resting place was Saitu, called Sachu by the Mongolians (Shachau of Marco Polo). Fruit and vegetables are here abundant; cotton is also cultivated, and the Chinese Governor has lately established a manufactory for weaving silk cloth. The climate is generally healthy and like that of Yarkand, though A——k was attacked by a peculiar disease in the legs, said to be due to walking barefoot on a particular kind of soil. In August 1881 the travellers left Sachu, and retracing their footsteps crossed the continuation of the Kuen Lun range† by a more easterly route than that they had previously taken, and found themselves on the Tibetan plateau, close by the sources of the Hoang Ho, which were afterwards visited by Prshevalsky on his last journey in 1884–85. They crossed the Ma-chu, as the upper waters of the Hoang Ho are here called, and travelled southwards by a lonely, uninhabited route leading across the Di-chu or Upper Yangtse-kiang to Kegudo, which is a place of trade. From this place A——k proceeded almost due S.E. in company with a trader for Darchendo or Tasienlu, and which was reached after a long journey on the 5th February 1882.* This city is a market, chiefly for tea, which is grown in gardens to the east and carried to Lhasa and to various places in Tibet, and even to Kashmir itself. The city is governed by a Chinese officer, assisted by several subordinate officials; there is also a Tibetan officer who possesses a jurisdiction over the original inhabitants. A——k was kindly received by two

* This part of the journey coincides roughly with that of Mr. Rockhill, formerly Secretary to the American Legation in Pekin. (*See* Proceedings of the Royal Geographical Society, p. 730 of 1889. Also Mr. R.'s book, published by Longmans, 1891.)

† *See* note on previous page.

Jesuit Fathers who lived outside the city, and by one of them he was presented with an introductory letter to his clerical brethren at Bathang and Darjeeling, and with a small gift of money. The same priest also apprised the Surveyor-General by letter of A——k's safety, which was a great relief to General Walker, as some alarming rumours had reached India in the meantime, owing to the absence of any precise intelligence.

A——k then set out on his return journey to India, proceeding due east by the regular official road through Lithang to Bathang. At the latter place the party diverged in a S.W. direction, and the Di Chu (Yang-tse-kiang), Chiamdo Chu (Mekong), and the Giama Nu Chu (Salwen)* were traversed in succession. The first of these rivers was crossed by a ferry, the second by a slanting leather rope to which men and even animals are attached in a sort of sliding cradle of rope. The Nu Chu, which is deep and rapid and 200 paces wide, was crossed by rafts propelled by oars, and prevented from going down the stream by some of the boatmen holding on to a rope stretched across the river. The Tila La pass westward (16,100 feet) gave the travellers their first access into the basin of the great rivers of Bengal, the river Zayul Chu which drains the valley being the same as Wilcox's Brahmakund and T. T. Cooper's Brahmaputra. The latter traveller succeeded in ascending the stream as far as the village of Prun.† A——k descended it as far as Sama, which is about 20 miles from the Assam boundary, and which is the place where Krik and Boury, the two French missionaries, were murdered in 1854.‡ The Zayul district belongs to a distinct hydrographical basin, and is warmer than any other part of Tibet. Criminals sentenced to transportation for life are sent thither. The inhabitants speak a very different language from that of the Tibetans, which, however, they understand. Many of their customs are more akin to those of the Hindus, and they raise two crops, harvested in the autumn and spring respectively.

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* This river has been generally hitherto assumed to be the upper course of the Salwen river, and this is the view I endeavoured to establish in my letter to the Royal Geographical Society (*see* Proceedings for 1883, p. 664). General Walker, however, thinks that it is more probably the source of the Irawadi; *see* Proceedings of the R.G.S. for June 1887.

† *See* The Mishmee Hills (London: H. S. King & Co.), p. 228.

‡ *See* Memorandum by Monseigneur de Mazure in Journal of the Asiatic Society, Vol. XXX.

At Sama A——k was informed that he would certainly be killed if he tried to pass through the Mishmi country, consequently he was reluctantly obliged to return by a northerly and circuitous route to Lhasa leading over the Neching Gangra range, which appears to be the eastern prolongation of the Himalayan chain.* The route lay in a northerly direction, and to the west of the Giama Nu Chu; many of the streams crossed draining into it. At the fort of Lho Jong the great high road from Darchendo to Lhasa was struck, and thence the route lay westward and fairly coincident with that followed by the Abbé Huc on his return journey from Lhasa to China, but instead of revisiting the capital, A——k travelled southwards to Chetang on the Brahmaputra, and finally arrived at Darjeeling on the 12th November 1882.

Such are the main features of this remarkable journey, which extended over 3,000 miles of country, and lasted over four years and a half. There is much of considerable interest in Mr. J. B. N. Hennessey's Report,† which it is impossible to reproduce here, but one important result was to demonstrate the fact that the great Tibetan river, the Sanpo, does not flow into the Irawadi basin, and that it has no other possible exit than through the channel of the Dihong. During the course of his travels A——k took observations for latitude at 22 stations, and heights by boiling point at 69 places. He displayed great ingenuity in secreting and preserving his instruments throughout all his troubles, and his perseverance and pluck in the face of disasters and privations earned for him the highest praise from his employers, and from all geographers. He was rewarded with a grant of a *jaghir* of land from Government, the title of Rai Bahadur, a grant of money from the Royal Geographical Society, a gold medal from the Paris Geographical Society, and one awarded by the Venice Geographical Congress. Still more meritorious were A——k's courage and perseverance amid difficulties sufficient to have daunted most men. Not only was he plundered

* A——k travelled down the Zayul river to about 10 miles below Rima; there he ascertained from native information only that it is the source of the Lohit Brahmapatra which flows into Assam. The accuracy of this information having been questioned, Mr. Needham, a British Police Officer in Assam, made an adventurous journey up the Lohit Brahmapatra to a point within a mile of Rima, and conclusively ascertained that the Zayul is the source of that river. *See* General Walker's paper on the Lu river of Tibet, in the Proceedings of the R.G.S. for June 1887.

† Report on the Explorations in Great Tibet and Mongolia, made by A——k in 1879-82. Dehra Dun, 1884.

by the Chiamo Golok robbers of nearly all his possessions, including the goods which had been provided, as usual, to enable him to traffic and pay his way, but when, still refusing to turn back and exploring further northwards, he was deserted and again robbed, this time by one of his two companions, who left him and his faithful comrade L——c practically paupers. He was then more than 1,000 miles, as the crow flies, from British territory, friendless and dependent on charity, yet he pressed on, keeping his face from home. Though for 2,000 miles he and L——c literally begged their way, yet he continued his observations to the very end with regularity, care, and skill, so that he rejoined the survey headquarters with all his little notebooks and instruments intact. His work proved to be of excellent quality and complete in every respect. Ordinarily explorers pay their way through their goods, and when these are expended, borrow money from friends or incur obligations which have to be made good. A——k was absent full twice the time of any other explorer, but when asked for the usual contingent bill, replied that he had paid nothing, and had no claim to prefer. Both A——k and L——c (who is the elder of the two) were quite incapacitated by the hardships and anxieties undergone from undertaking any similar work in future.

It should be mentioned that a small portion of A——k's route was subsequently traversed by Mr. A. D. Carey, of the Bombay Civil Service, whose journey, though not that of a member of the Indian Survey Department, may be briefly noticed here, especially as he bears testimony to the accuracy of A——k's work. Mr. Carey started from Leh in August 1885, and, in company with Mr. Dalgleish, who acted as interpreter, proceeded to Kiria, in the Tarim basin, through the uninhabited tract of Tibet lying between the Pangong Lake and Polu. He then travelled to Khotan and traversed a large portion of the great desert, first following the Khotan river to Shah Yar, and then the course of the Tarim river to Lake Lob. From thence he travelled southwards, ascending the various huge ranges of mountains which here buttress the northern face of the Tibetan highlands, till he reached a lonely point called Mugzisolma, near the upper waters of the Yangtze-kiang, and south of the Angirtakshia pass over the Kuen Lun range. He then turned northwards through the Naichi valley, where good grazing and plenty of firewood and water were obtained, and having abandoned the intention of proceeding further south in the direction of Lhasa

on account of the difficulty of getting supplies, he returned through the Sirthang plain and Sachu (both of which had been visited by A——k), and from Nainshe crossed the desert to Hami. From the latter place he followed the usual route along the foot of the Tian Shan mountains through Turfan, Karashahr, Kuchar, Aksu, Yarkand, and the Karakoram pass to Ladak.

The journey forms an extremely interesting link between the discoveries of Prshevalsky in his two Tibetan journeys of 1879–80 and 1884–85 and those of the Indian explorer A——k, and was of such importance as to earn for its author the gold medal of the Royal Geographical Society.

A great deal of geographical and general information respecting Tibet has been collected within the last few years by two native officials of the Bengal Educational Department, viz., Babu S. C. D. and the Lama U. G. In 1879 S. C. D., being about to journey to Shigatze on business of his own, and anxious to make the most of his opportunities for acquiring new geographical information, underwent a course of training in surveying and observing, under the Pundit Nain Singh. He then set out from Jongu, in Sikkim, and, traversing the north-east corner of Nepal, crossed into Tibet by the formidable Chatang La pass and travelled northwards to Shigatze, on the Sanpo. He returned by much the same way to near Khamba Jong, and re-entered Sikkim by the Donkia pass. His journey was fruitful of information, the observations of bearings and distances were carefully taken and recorded, and of much value for mapping.

S. C. D. is the author of a "Narrative of a Journey to "Lhasa, 1881–82," with a supplementary paper on the Government of Tibet.* The work, though at times overladen with traditions and legends, is a most interesting and valuable description of the journey, of the country, and of the people, though the geographical information is rather meagre. The route followed by him and his companion in 1881 starts from Darjeeling and runs by way of the Kongla-chen pass, Tashi-Lhunpo, Dong-tse, and the Samding monastery to Lhasa, and thence back again to Darjeeling.

S. C. D. intended to publish a second volume, containing a narrative of his journey round Lake Palti, a series of papers on the

* Bengal Secretariat Press, Calcutta, 1885. 207 pages. The Secretary to the Royal Geographical Society has informed me that they propose to bring out a carefully edited abstract of this work.

history, antiquity, customs, manners, &c. of the people of High Asia, and an account of the explorations of Lama U. G., but the author does not appear to have carried out this intention. Of the Lama U. G.'s second journey no record appears to exist, though the results of all the three journeys were embodied by Colonel Tanner in the S.W. section of sheet 6 of the N.E. Transfrontier Series of maps. Of the third journey a short account has been prepared by Colonel T. H. Holdich.* One of the most interesting features of this journey was the Lama's complete account and survey of the famous Yam-dok-tso or Palti lake.† This lake first appeared on the map prepared by D'Anville from the Lama survey, and published by Du Halde in 1735. It was there shown as a ring-shaped lake, and so represented on all later maps, but the explorer L., who travelled in Tibet in 1875 and 1876, and A——k, who passed it on the 31st August 1878, both remarked that the so-called island in the centre was in reality connected with the mainland. The true name of the lake was reported by the Lama to be Yamdok or scorpion lake, an appellation which shows that the Tibetans must have had some maps, giving a fairly correct idea of its shape. Villages and monasteries are dotted on the margin of the lake, which is embosomed by mountains, except at its eastern extremity, where there stretches a far-reaching plain of rich sward, on which graze thousands of cattle, horses, and beasts of the chase. On the hilly peninsula, which is encircled by the two scorpion claws, is an inner lake about 24 miles in extent and 500 feet above the level of the Yamdok lake, and on its shore is the great Samding monastery, where S. C. D. was very nearly breathing his last.‡ The question of an outlet to Lake Yamdok is still left in uncertainty, though the probability is that its waters find an outlet down the Rong-chu into the Sanpo. The Lama brought back a wonderful native story, that occasionally the waters of the Sanpo rise and those of the lake sink, so that the flow of the Rong-chu is then the other way. The altitudes, however, make this an impossibility. The Lama then proceeded southward by the Pho-mo-chang-thang-tso lake (16,050 feet), respecting which he was the first traveller to bring back any information, to the Menda La pass (17,450) feet, which leads over the

* Report on Explorations, &c. in Sikkim, Bhutan, and Tibet. Dehra Dun, 1889.

† A good deal of interesting information respecting the Palti lake will be found in a note on page 244 of Mr. C. R. Markham's Tibet: Bogle and Manning (Trübner).

‡ *See* page 116 of "Narrative of a Journey to Lhasa in 1881–82." Calcutta, 1885.

water-shed of the central Himalayan chain* into the valley of the Lhobra Sanpo river or upper Manas. Here he had struck into the Indian hydrographical basin, and very soon he entered a well-peopled and highly cultivated valley, resembling Sikkim, and said to be the most fertile in Tibet. At Lhakhang-Jong, a little north of the frontier, the Lama's goods were searched and his true character as an explorer was revealed to the authorities, but by dint of judicious bribes and his skill in meeting cross-questioning, he was allowed to depart, his fair note book being alone destroyed. He then made his way north-eastward, and passing through Chetang, on the banks of the Sanpo, and the great Sam-ye monastery, probably the most important in Tibet, he arrived at Lhasa, where he stayed for a few days and had a friendly interview with the Nepalese agent. He returned to India by way of the Yamdok-tso and Pho-mo-chang-thang-tso lakes, and the Chumbi valley to Darjeeling, which he reached on the 15th December 1883.

The valley of the Arun river was traversed in 1880–81 by a Hindu explorer, G. S. S., up to the water-shed between Nepal and Tibet. Crossing the mountain range he advanced to the Tibetan village of Karta, beyond which he was not allowed to go. He brought back some new information respecting routes in Nepal, though his observations were few and disconnected.

During 1884–85 the designation of the Darjeeling party was altered to that of the Himalaya party, and under the superintendence of Colonel Tanner a variety of work was performed. The blocks for tea cultivation in the Darjeeling hills were demarcated with permanent pillars, progress was made with the demarcation of the Nepal boundary, and triangulation over 550 square miles was executed in the Simla Hill States.† The most important part of the operations, however, consisted in the triangulation carried on in the following localities, so as to extend our knowledge of the Himalayas, viz., (*a*) on the Gandak river, (*b*) from stations of the North-East Longitudinal Series in the plains facing Eastern and Central Nepal, (*c*) in the *terai* along the Mechi river, and in the Daling hills from bases

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* *See* my article *Himalaya Mountains* in the "Imperial Gazetteer of India," for a general view of the structure of the mass of the mountain range referred to. Colonel Godwin-Austen also submitted an elaborate map and address on the same subject before the British Association at Southport in 1883. *See* Proceedings, Royal Geographical Society, 1883, p. 610, and 1884, p. 83.

† *See also* p. 99.

derived from the Darjeeling survey, (*d*) from the stations facing Western Bhutan, based on the data of the Assam Longitudinal Series, and (*e*) from the stations in Eastern Kumaun facing Western Nepal and Tibet.

The last-named operations were conducted by Colonel Tanner in person, assisted by R —— N——. They crossed the Lipu Lek pass (16,800 feet) at the north-eastern corner of Kumaun, but were ordered back by the Tibetan Governor of Taklakhar, on approaching that place. Colonel Tanner says that the Lipu Lek pass is one of the easiest between India and Tibet, and though the surrounding tracts are not so populous as Eastern Tibet and the road between the pass and Kumaun most arduous, the trade in grain, salt, and borax is already very considerable. The Jong Pon or Governor of Taklakhar asked Colonel Tanner what object the English had in making roads in Kumaun, and why they wished to leave the beautiful plains of India for such a barren country as Tibet? How was it that the English were always craving for the territories of others? Colonel Tanner replied that the English did not in the least desire to occupy such a comfortless and bleak land as theirs. "Bleak, do "you call this?" was the rejoinder, "Why, you are now in the "very garden of Tibet! If you call this barren what would you say "of other parts where there is literally nothing but rock and ice? "Go back now to India, you have seen the most inviting (!) part of "our country, the rest is not worth a visit. Our Government don't "allow the English in Tibet; but you, one and all, try to push "your way past our frontier posts, and never consider that, if you "succeed, our governors and officials on the frontier lose their heads "for not stopping you!"

The scenery a few hours below the Lipu Lek is remarkably fine. Below Budi, in the Kali valley, a series of stone steps or ladders commences, over which the traveller has to make his way for a day and a half before he reaches an ordinary mountain-path. This extraordinary trade route consists of a kind of winding staircase, cut into the rocky face of the cliffs, and in many places overhung with crags, with a seemingly bottomless abyss below. On Colonel Tanner's return to India the whole flight of steps was literally crowded with thousands and thousands of laden sheep and goats, making their way up into the high lands of Tibet; and the perils were increased by the sheep obstinately rushing past regardless of the consequences to themselves or others. Many animals are annually

precipitated over the cliffs, and how the trade has been carried on under circumstances of such exceptional difficulty is a marvel.

R—— N——, who was Colonel Tanner's companion through the above work, also completed the very arduous undertaking of a circuit round the great Kanchanjanga mountain, not only supplying a sketch of the peak and its dependent spurs, but also a delineation for the first time of the boundary between North-eastern Nepal, Sikkim, and Tibet.

In 1887–88 the reconnaissance and approximate triangulation of Western Nepal were extended eastwards from the Kumaun boundary to the Gandak river, which has formed a sensible addition to our geographical knowledge of that country. But a good deal still remains to be done. Materials are most scanty where the Gandak and Baghmati rivers break through the Himalayas into the plains, and most abundant, of course, in the tracts adjoining Kumaun and Sikkim, whither observers have been able to gain access without difficulty. The greater part of the operations in 1887–88 were done by Sub-Surveyors Rinzin Nimgya and Ram Saran by distant sketching from the tower stations of the N.E. Longitudinal Series of the Great Trigonometrical Survey and with the aid of previously fixed distant peaks, a method which enables the Surveyor to fix fairly enough the prominent points of ridges and any other features seen and identified, but which leaves him somewhat in the dark as to the run of the valleys and the details of the drainage. Besides these reconnaissance surveys the only other information we possess is derived from the route surveys of the few native explorers who had traversed the country from time to time, and from a survey by Major Wilson and Captain Barrow of the valley of Khatmandu. The chief difficulties attending Himalayan surveying of this character are due to the hazy and cloudy state of the atmosphere, which nearly always obscures the central band of mountains.

Bhutan is another region of which our knowledge is still very fragmentary, and this appears to be mainly due to frequent internal dissensions and the generally unsettled character of the country. According to R. N., who explored tracts in Eastern and Western Bhutan in 1885–86,* the government is nominally vested in two

* Report on the Explorations of Lama Serap Gyatsho and four other native travellers in Sikkim, Bhutan, and Tibet. Dehra Dun, 1889. An interesting critical review of the journey, giving many additional details, will be found in the Indian Survey Report for 1886–87, page lxxxvi.

functionaries, the secular head or Deb Raja, and the religious head or Dharma Raja, but the real power lies with several chieftains, who are always plotting against each other to set some relative of their own on the throne. Hence R. N. and his companion P. A., who had entered Western Bhutan from Sikkim and the Chumbi valley, were unable to continue their journey eastward across the country as Pemberton had done in 1838, and were compelled to travel southward to Buxa Duar, re-entering Bhutan at its eastern extremity at Dewangiri. From this point they travelled to the north-west, ascending the Pumthang river, one of the principal feeders of the Manas, up to the Tibetan frontier, and thence travelling eastward returned by way of Tawang. The route closes on to that of Captain Pemberton (1838) in Bhutan, and of Lama U. G. in Tibet, and the results have helped greatly to supply a sketch map of Bhutan, which has been embodied by Mr. W. G. E. Atkinson in sheet No. 7 of the N.E. Transfrontier Series. One result of the journey was to prove that the Kuru or Lhobrak Chu is the largest river of Bhutan, and drains the country between the Yamdok, Pho-mo-chang-thang, and Tigu lakes, and the glaciers of the Kulha, Gangri, and other great ranges.* R.N. also discovered a new tribe called Chingmis in the eastern part of Bhutan. Though resembling the Bhutanese in dress, they differ in wearing pigtails, are of a more amiable disposition, and live in better houses, but do not, like the Bhutanese, form part of the official class.

An account of the lower Sanpo was written by the Mongolian Lama Serap Gyatsho between 1856–68. His narrative,† however, is mainly confined to a list of names of monasteries, sacred places, and villages, with an occasional digression into history, description of wild beasts, &c. It contains but little geography, and being based, moreover, on data collected nearly 30 years since, must be altogether accepted with caution. Nevertheless, the information, such as it is, combined with the account of K——p (a more recent explorer) enabled Colonel Tanner to compile a sketch map of that part of the Sanpo which had been previously a complete blank on the maps.

* Geographers appear to have been in some uncertainty regarding the lower course of the Lhobrak. In my article on the "Himalaya Mountains," in the "Imperial Gazetteer" of India, I suggested that the Manas was in reality the lower course of the Lhobrak; but in Mr. Markham's work "Tibet: Bogle and Manning," the Lhobrak-chu and the Subansiri are supposed to be identical.

† *See* footnote on previous page.

K——p, the explorer just referred to, is a native of Sikkim, and had accompanied G. M. N. (another employé whose work is referred to on the next page) to Gyala Sindong on the Sanpo, besides having since traversed Bhutan with R. N.* K——p went as servant to a Chinese Lama whom the late Captain Harman sent to Gyala Sindong to throw marked logs into the Sanpo, having previously arranged for watchers to be stationed at the junction of the Dihong and Brahmaputra to ascertain whether the logs came down by that course, and to settle by this means the identity of the Sanpo with the great river of Assam. The Lama proved a faithless rascal and having sold K——p returned to his own home in China. K——p managed to escape and return to Darjeeling after an absence of four years, having traced the course of the Sanpo down to Onlet, nearly 100 miles lower than any previous explorer and to within one march of Miri Padam, which is said to be only 35 miles from the nearest plains of India. K——p not being a trained explorer the information he brought is not based on a route survey, and can only be regarded as a bonâ fide story of his travels related from recollection two years after his return. The account was translated into English from the original by Norpu.

From Gyala Singdong downward the river is enclosed by snow-clad mountains on which the wild yak and Tibetan stag abound. The country is here called Pemakoichen, and is inhabited by Chingmis, a race which R. N. had met in north-eastern Bhutan (*see* particulars on preceding page), and which occupies a considerable extent of country eastward as far as the Sanpo. They resemble partly the Bhutanese and partly the Men tribes around Tawang. Those in Bhutan are described as more amiable than the Bhutanese proper, and as living in houses of better construction, while their affinity to the Chinese is shown by both sexes wearing pigtails. They extend as far as Daugam on the Sanpo river, where the Lo river joins it. Below that point Tibetan names and influence cease, and the country of three tribes of aborigines called collectively Lo Kabta† commences. They are averse to anything savouring of Buddhism or Tibetan habits; they

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* For narrative *see* "Report on Explorations in Sikkim, Bhutan, and Tibet." Dehra Dun, 1889. See also Colonel Tanner's interesting "Notes" in the Indian Survey Report for 1886–87, page lxxxvi.

† Compare the Lhòk'haptra of De La Penna and L'hok'hapha of Klaproth. *See* Markham's Tibet, pages 311 and 312.

are great hunters, and shoot either with bows and arrows or with matchlocks the bison and other game which is found in plenty on the mountain slopes. The Padams at the lowest portion of the Sanpo reached by K——p are known to us, on the authority of Mr. Needham, as Abors.

An important piece of geographical discovery in connexion with the course of the great river of Tibet, the Sanpo, was accomplished, in 1878, by a Sikkim Bhutia G—m—n, who had been trained by Lieutenant Harman, R.E., in the use of the prismatic compass, in plotting his work, in the use of a boiling-point thermometer, and the reading of a sextant. This traveller followed the course of the river from Chetang, a village visited by the Pundit Nain Singh, in an easterly direction to the Chamkar monastery (Tchamca of D'Anville), beyond which the river makes an acute bend and flows south past Gyala Syndong (the furthest point reached by G—m—n) and the Gimuchen country into a country which the natives say is "ruled by the British." This journey thus threw considerable light on the further course of the Sanpo and (assuming it to be one and the same as the Dihong of Upper Assam) reduced the unknown section of the river to about 100 miles, a distance which was eventually diminished still further by the journey of K. P. in 1886–87 (*see* preceding page), which may be considered as the complement of G—m—n's exploration. The latter traveller also brought back particulars of various places in the valley of the Sanpo which are to be identified with names of D'Anville's map. He also visited the Yamdok-tso or "Palti lake" of D'Anville and furnished an interesting description, with sketches of the great iron suspension bridge at Chazumtuka or Chagsum by which travellers bound for Lhasa from the south-west cross over the Sanpo river.

Burma and Assam Frontier.—The opening up of the Assam frontier was pressed on the attention of the Secretary of State even before the annexation of Upper Burmah. On the 31st July 1878, a deputation, headed by the late Mr. W. E. Forster and Sir R. Alcock, and comprising Col. Godwin-Austen and various gentlemen interested in Assam and its tea-trade, waited on Lord Cranbrook at the India Office with a memorial praying for the improvement of the communication between Calcutta, Assam, and China, and for preliminary exploration along the connecting route across the mountains. The matter was commended to the notice of the Government of India on the 29th August 1878 (Despatch No. 46 (Geographical)). The papers

which form Appendix B. to G. T. S. Report for 1876-77 (*see* Survey Proceedings for April 1878) contain some interesting details as to the geography of N.E. Assam, and a Note (Appendix B.) on the old Burmese route over the Patkoi and by way of Nongyong, viewed as the most feasible and direct route from India to China. The deputation undoubtedly helped to concentrate attention on this important region, and some useful explorations were subsequently made (*see* Topographical Survey chapter, p. 79).

The military events in Upper Burma leading to the deposition of King Theebaw and the annexation of the country to the British Crown, necessitated the employment of surveyors, and in the spring of 1886 Captain Hobday left the Andaman islands,* which he had been engaged in surveying, for Mandalay. The latitude and longitude and altitude of that city were determined, and a preliminary map of the surrounding country was compiled from the reconnaissances of officers with the Burma Field Force. In May Captain Hobday and Sub-Surveyor Ahmad Sayad accompanied a military expedition into the Kachin hills, south-east of Bhamo, and in the following month one to the south-east of Mandalay. While carrying on his work at a place eight miles east of Kyonkse, Ahmad Sayad was attacked by Shan dacoits and killed. The despatch of a telegraph party to lay a line from Mandalay to Bhamo gave opportunity for the extension of the triangulation and topography northwards up the Irawadi. The survey of the city of Mandalay on the 6-inch scale, covering altogether an area of 50 miles, was completed as well as a sketch map of the new cantonment site at Bhamo.

In the later part of 1886 the survey detachment in Upper Burma was strengthened and enlarged, and several reconnaissances were made in connexion with the various military movements undertaken for the pacification of the country. In November Captain Hobday and a sub-surveyor accompanied a column from Mandalay to Thonze *viâ* Pym-ul-win and returned by the same route. In January Captain Hobday joined another expedition from Mandalay to the Shan State of Mainlon, *viâ* Lamaing and Kalagwe, and then

* A good account of the Little Andamans (which Professor Flower has described as one of the most isolated spots in the civilised world) was given by Mr. M. Portman, before the Royal Geographical Society on the 30th January 1888. *See* Proceedings Royal Geographical Society, p. 567. The Great Andamans are better known, and an admirable article on the two groups, from the pen of the late Sir Henry Yule, will be found in the *Encyclopædia Britannica*.

proceeded with the troops to the Ruby Mines, returning from Mogok, the ruby-mining centre, to Thabeitkyun on the Irawadi. He also took advantage in March of the return of the Tsawbwa of Thibaw from Mandalay to his capital, under escort, to accompany the party which travelled through Nammaw and Goteik to Thibaw, where he halted and explored the surrounding country. The area reconnoitered and mapped during these various expeditions in the Northern Shan States and the Ruby Mines district amounted to about 3,000 square miles. Major Hobday remarks of the Shans that he believes them to be a peace-loving community, who have only been excited to wage war one against another by the intriguing resident Burmese officials appointed from time to time by the Burmese court. They are naturally very fond of trade, and along every road are to be met hawking their wares. The country is very deserted in parts owing to the petty wars and disturbances prevalent of late years. Lieutenant Jackson, the next officer in charge, was similarly engaged with various expeditions, and his out-turn, together with that of the sub-surveyor with him, also amounted to about 3,000 square miles of reconnaissance survey.

The general results of the work of these officers, as well as that accomplished by Mr. Wyatt and others belonging to the Upper Burma party, consisted of an area of 15,000 square miles triangulated and 11,000 square miles of reconnaissance survey. The difficulties in a country like Upper Burma are very great owing to the dense forests, undergrowth, and high grass encountered almost everywhere, in addition to which an impenetrable haze fills the air from March to the commencement of the rains. These drawbacks, coupled with the necessity of keeping up with troops marching from 10 to 15 miles a day, rendered the carrying on of a connected triangulation and topography a matter of great difficulty, and Captain Hobday and his coadjutors received the special commendation of the Commander-in-Chief for their labours.

A small survey party accompanied the military column which was despatched from Assam by way of Manipur into the Chindwin valley to co-operate with the field force in Upper Burma, and Colonel Woodthorpe, who had just returned from Gilgit, where he had been for more than a year with Sir W. Lockhart's mission, at once volunteered for the work. He selected as his assistant Mr. M. J. Ogle, who had previously accompanied him in various expeditions on the north-east frontier. The results comprised

360 square miles surveyed topographically on the ½-inch scale in the south-east of Manipur, in continuation of the survey of 1881–82; the whole of the Kubo valley and large portions of the Lekayain district, comprising an area of 3,924 square miles, was surveyed on the ¼-inch scale, as well as part of the course of the Chindwin river. Colonel Woodthorpe was seized with a bad attack of fever, which lasted during May, but Mr. Ogle energetically continued the triangulation and succeeded in effecting a junction with Captain Hobday's series, brought up from Mandalay.

In recognition more especially of his services in Burma Colonel Woodthorpe was appointed a Companion of the Order of the Bath, a distinction which afforded much gratification to all those who had watched that officer's record of services in Afghanistan, Assam, Upper Burma, and Hunza, and of other dangerous enterprises.

During 1887–88 Major Hobday extended the triangulation from Mandalay northwards to Bhamo, while Captain Jackson and two surveyors accompanied a column despatched from Fort Stedman into the Southern Shan States. Reconnaissances were made towards the Salwen river, and its course fixed at two points. A highly satisfactory connexion with Major Hobday's triangulation was effected, the total circuit of the combined reconnaissances being over 600 miles. A portion of the route traversed by the southern column had been followed by the party accompanying the Salwen expedition in 1864–65,* and the work then executed by the late Mr. F. Fedden, of the Geological Survey Department, was tested, and its general accuracy fully established.

The Southern Shan States expedition was altogether a great success; the British were received everywhere in the most friendly manner, and its effect was to re-establish peace instead of the inter-tribal wars till then prevalent.

To the Northern Shan column Sub-Surveyor Faida Ali was attached, and the area mapped by him amounted to 3,425 square miles, north-east of Mandalay and stretching eastward to the Salwen river, which here as well as in the upper part of its course flows closely to its western water-shed, leaving a wide expanse of country beyond to the share of the Irawadi.

In the country west of the Irawadi a large area was reconnoitred in the Chindwin, Pakokku, and Minbu districts by four columns which advanced into the Yaw country. Mr. Wyatt, who

* *See* the Memoir on the Indian Surveys, 2nd ed., p. 229.

accompanied the southernmost column, extended the triangulation down the Irawadi to Thayetmyo, in the vicinity of which he effected a junction with the principal series of the Great Trigonometrical Survey.

Another column operated in the country above Mogaung, and visited the Jade mines north-west of Sakaw as well as the Great Endawgyi lake seen by Mr. Strettell, Deputy Conservator of Forests to the Government of India, on the occasion of his exploring trip in 1873-74. For fear of exciting the Kachins it was deemed advisable not to ascend the hills. Triangulation was thus rendered impossible, and opportunities of acquiring topography were lost. Some useful miscellaneous surveys were executed by Mr. G. H. Powell, but while in the vicinity of Konni, a new military post which had been formed on the Shan plateau, about 30 miles west of the Inlè lake, an unfortunate quarrel arose with villagers, and in the ensuing struggle Mr. Powell and two Burmans were killed. This young officer's death was much regretted, for though he had been only a short time in the Department he had shown much ability and promise.

The general result of the year's operations was an area of 23,274 square miles triangulated and 20,780 mapped on the ¼-inch scale, an out-turn which bears witness to the great activity of the Departmental officers in the difficult circumstances imposed by the unsettled condition of the country.

In addition to these reconnaissances a special survey was undertaken of the Ruby Mines tract, and the entire area within which the mines lie, amounting to 77 square miles (a far larger extent than previously imagined), was mapped on the 6-inch and 2-inch scales.* Large scale surveys of the town and suburbs of Mandalay for settlement and other administrative purposes were also completed in 1888.

The reconnaissance survey of Upper Burma by Major Hobday's party proceeded steadily during the following year (1888–89). Survey officers accompanied the various military expeditions which were organised during the year, and proceeded to the Chin country, to the Kareni and the Southern Shan States, to the Northern Shan States, and to Mogaung and other parts of the Bhamo district, against the Kachin tribes. Surveys of a more regular character were also carried on in the Minbu, Myingyan, Sagain, and the Ruby Mines districts. The year's out-turn amounted to 20,510 square

* Mr. R. Gordon, C.E., read a paper on the Ruby Mines before the Royal Geographical Society on the 27th February 1888.

miles mapped on the quarter-inch scale, the greater portion of which lay in the Shan States and Bhamo district. In 1889–90 one party was at work in lieu of two, and the out-turn was a little smaller. But the total area mapped during the last four years in Upper Burma amounts to 70,852 square miles, a result most creditable to Major Hobday, Captain Jackson, Mr. Ogle, and the other members of the party. To Mr. Ogle the Gill Memorial Medal for 1889 was awarded by the Council of the Royal Geographical Society in recognition of his excellent survey work in the North-eastern frontier and in Burma.

A small survey party under Lieutenant W. H. Pollen, R.E., an energetic and popular young officer, accompanied the military expedition to the Lushai Hills in 1888–89; but owing to the unfortunate illness and subsequent death of Lieutenant Pollen, but little work was done, though the information acquired by Mr. James, who succeeded to the charge of the party, proved very useful in the following year. The expedition in that year (1889–90) consisted of two columns, one starting from Kan, in the Myittha Valley, and proceeding into the Chin Hills, and the other from Chittagong being directed into the Lushai Hills. Each column was accompanied by a small survey party under Lieutenants Renny-Tailyour, and Bythell, R.E., respectively. The operations in the Chin Hills resulted in the survey of about 3,000 square miles, and those in the Lushai Hills of about 6,000 square miles of new country. The triangulation of both parties were successfully connected near Haka.

A survey party, under Captain Jackson, R.E., which accompanied the Anglo-Siamese Boundary Commission, mapped over 9,000 square miles on the $\frac{1}{4}$-inch scale. Mr. Ogle, who was a member of the survey party, was detached at the outset to work independently, with instructions to survey the four States of Möng Ton, Möng Hang, Möng Chut, and Möng Tar. This he successfully completed.

In conclusion, mention should be made of an interesting piece of work, which though carried out some years previously, helped to throw a good deal of light on the conterminous region of Upper Burma and Assam. In the early part of 1879 Captain J. E. Sandeman, in charge of the cadastral survey in the Hanthawadi district of British Burma, was requested to train a native for exploring the upper course of the Irawadi river beyond Bhamo. Towards the end of the year the man had acquired a sufficient knowledge of his duties to be started on a preliminary

exploration, and in November 1879 he started with two companions, and soon after arrived at Bhamo. Thence the party ascended the river in boats to Ka-cho, once an important city, in latitude 25° 20′, at an elevation of about 1,000 feet above the sea. At the village of Maigna, about 16 miles north of Ka-cho, the Burmese frontier was reached. The country beyond is inhabited by Kachins, among whom no Shans reside, and the people pay no tribute to Burma. Two days afterwards the junction of the eastern and western branches of the Irawadi river were sighted, the latter (called the Maleeka) being considerably swollen and 500 paces wide, while the eastern branch (called Mehka) was low and flowing amid rapids and large rocks, with a width of about 100 yards. The people of the country stated that the great increase in the waters of the western branch was due to the melting of the snow at its sources, and there can be little doubt that it is the larger, and rises in higher ranges. The natives also stated that the eastern branch has two principal affluents, one from the east, and believed to have its source in the Naungsa lake, and the other from the north, said to rise in the hills 50 or 60 miles beyond Mo-goung-poon. The sources of the western branch are stated to be in the Kantee country, at a distance of about 23 days' journey from Ka-cho. Thus it is highly probable that this is the branch of the river reached by Wilcox in his journey from Assam in 1827, which is described in Vol. XVII. of the Researches of the Asiatic Society of Bengal (Calcutta, 1832). The explorer's "Kantee" is obviously identical with Wilcox's "Khanti."*

The trustworthiness of the explorer's investigations is proved by a comparison of the three maps, viz.:—Lieutenant Wilcox's, of 1828; Father Desgodins' map of the eastern frontier of Tibet, presented to the Asiatic Society of Bengal; and the explorer's own. These are skilfully juxtaposed by the Surveyor-General of India in his Report for 1879–80, and the general agreement is substantial and striking. It is quite conclusive against the old theory of the identity of the Sanpo and Irawadi.

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* Major Sandeman read a paper on the journey before the Royal Geographical Society on the 27th February 1882. *See* Proceedings, p. 258.

VII.

AFGHAN BOUNDARY COMMISSION.

An enormous addition to our knowledge of northern and western Afghanistan was made by the labours and researches of the Boundary Commission, which was engaged, in conjunction with a Russian Commission, in laying down the northern boundary of the country in 1884–86. Unlike the Eastern Persian Mission under Sir F. Goldsmid, and the Yarkand Mission under Sir D. Forsyth, of which official narratives were duly compiled, an official account of the Afghan Boundary Mission has not yet been written; but the following details, culled from various published sources, but chiefly from the excellent papers contributed by Lieutenant-Colonel T. H. Holdich to the Royal Geographical Society's Proceedings, will give a general idea of the geographical results achieved.

The Indian section of the Afghan Delimitation Commission left Quetta on the 19th September 1884 under the command of Lieutenant-Colonel (now Sir) J. W. Ridgeway. A small survey party was attached to the Commission, consisting of Captain St. G. Gore and Lieutenant the Hon. M. G. Talbot, assisted by three native sub-surveyors. It was subsequently decided to depute a third officer, and Major J. Hill, R.E., was at first selected, but in consequence of his weak state of health he was unable to proceed further than Quetta, and Major Holdich was recalled from the Zhob valley expedition to take his place.

The triangulation laid out by Lieutenants Talbot and Wahab in 1883 to the south and south-west of Kelat formed the basis for an extension of the Afghan triangulation from Nushki to the Helmand. But the extension was carried out with great difficulty, owing to the thick haze, and Captain Gore and Lieutenant Talbot were unable to keep up communication between their respective series; but, nevertheless, a fairly satisfactory junction was effected at Galichah,

just east of the Helmand. The distance from Nushki was about 220 miles, and the country was most barren and difficult; but the position was important to fix, as Nushki is an oasis commanding the highways which lead from Quetta to Seistan. Westward for 70 or 80 miles no streams or springs exist, but the low-lying partially sand-covered "put" or hard-baked mud-flats form the edge of the basin which receives the waters of the Lora from the Pishin valley at flood times. Within the limits of the Hamun or final swamp of the Lora water is practically found everywhere near the surface.

The God-i-Zirreh or terminal swamp formed by the Helmand is very similar to the Lora Hamun. The Helmand river flows through a depression about 30 miles north of the God-i-Zirreh, and then turning north at Chahar-burjak passes into the swamps which form permanent lakes south of Lash-Jowain. In the late autumn of 1884, when the Afghan Commission was on the march to Lash-Jowain, the flooded part of the Seistan Hamun extended very little further than the limits represented as "permanent lake" in Walker's map of Turkestan. In 1885, however, on the return march of a part of the Commission, Mr. Merk found that the floods extended southwards and were connected by a well-defined channel with the God-i-Zirreh. The level of the eastern end of the latter depression immediately south of Rudbar is probably 500 feet lower than the Helmand, and between the two there must be a dividing water-shed of a considerable elevation towards the east but falling away to the west. From Khoja Ali to Chahar-burjak, where the great northern bend commences, the Helmand forms a series of picturesque reaches, often sub-divided into many channels and encompassing islands green with tamarisk, Euphrates poplar, and occasional fringes of grass. The white ribbon of silt intersected by the deep blue of the stream is generally flanked with a mile or so in width of pebble-covered, sandy "dasht." Beyond stand up the deep-cut and many-folded sand cliffs, presenting an infinite variety of red and purple tinted wall. On the left bank many traces of a long disused irrigation system were observable, and near Rudbar a series of ruined houses, forts, and palaces commences, the Kala-i-Madre-i-Padshah being the most remarkable. A variety of Arab, Assyrian, Greek, and even Chinese coins were brought thence to the English officers for sale. Nowhere else did the Commission find evidences of a once highly civilized and prosperous state so strongly marked,

and the great grassy plain east of Kala Fath bears the appearance of being the gigantic graveyard of successions of buried cities. Kala Fath, itself the ancient capital of the Kaiani Kings, is still an imposing mass of ruins.

At Kala Fath, where the route turned northward, a new system of surveying was introduced, and the distances were checked by observed latitudes at each halt till Ibrahimabad was reached, 50 miles beyond. From thence the latitude and longitude were carried out vigorously by means of observed latitude and azimuths and such triangulations from short independent bases as might be possible. Simultaneously with the running triangulation a plane survey of the whole country was executed on a scale of four miles to the inch, based on a perambulator traverse combined with the trigonometrically fixed points. This survey included, roughly, a strip of country averaging some 20 miles in width. The whole work was completed with both accuracy and speed, the entire distance as far as Kushan (310 miles) being covered in 19 days.

From Kuhsan the method of surveying was as follows:—Triangulation was carried on with Troughton and Simm's 6-inch "subtense" theodolites as opportunity offered, along several lines, each of which finally resolved itself into a series more or less complete. The following were the main series:—

1. From Kuhsan to Mashhad.
2. From Kuhsan along the Hari Rud valley to Bamian.
3. From Bamian viâ Haibak to Balkh.
4. From Zulfikar (on the Mashhad Series) to the Oxus at Khamiab.
5. From Andkhui (on the "Boundary" or No. 4 Series) to Balkh, thus completing circuit.
6. From Kuhsan southward to Birjand along the Persian border.

In the course of this gradual extension many detached bases were measured, and new linear values imported into the work together with new azimuths. Astronomical checks were introduced when observations could be taken over a sufficient number of days to ensure trustworthy results. In this the officers of the Commission were assisted by Captain Guedeonoff of the Russian staff, who was able to verify the results by observations with a Repsold instrument of a much higher class than the small English theodolites. His results, however, agreed closely with those of the latter. On the

basis of this triangulation all the topography was executed, whether by the Russian topographers on a comparatively large scale along the line of the boundary, or by the British officers and sub-surveyors, who not only took up their share of boundary topography, but extended smaller scale geographical work over a vast area in Persia and Afghanistan amounting altogether to over 110,000 square miles. The scale adopted was usually four miles to the inch, occasionally reduced to half that scale where the triangulation was not close enough to furnish a sufficient number of points within the limits of the plane-table. The plane-table was the ordinary Indian service pattern of the largest size, 36 in. × 24 in.

From Kala Fath northward to Lash-Jowain the narrow valley of the Helmand afforded no extensive view east or west; for 30 miles villages are scarce, though Ibrahimabad and its neighbourhood appeared to present a magnificent field for antiquarian research, old seals, coins, and rings being brought to the camp for sale in great numbers; all this part of the Helmand valley having been evidently thickly inhabited in early times. The eastern Hamun or depression into which the Helmand flows presented a striking appearance. The dark blue green of the surface was flecked with white foam, and the miniature waves were driven shorewards before the fierce intensely cold blast of the westerly winds. Reed islands broke the level here and there, and myriads of duck rose from the banks and islands and rotated over the surface of the swamp well out of reach. The expanse of water, however, as seen in October 1884 was nothing to what it appeared to Mr. Merk in November 1885, when the two swamps had united into a vast lake and spreading themselves southwards had spilled their waters into the God-i-Zirreh of Baluchistan.*

Jowain, a collection of mud buildings dome-roofed and in good repair, on the left bank of the Farah-Rud, and Lash, picturesquely perched on the edge of the opposite cliffs overlooking the river, are both marked specimens of the peculiar Perso-Afghan style of town, which extends throughout the border to Herat and Kandahar. Rows of mud-built huts with beehive roofs clustering confusedly round the walls of a central half-ruined mud fort re-occur with monotonous regularity. The substitution of flat roofs in some of the larger

* Some particulars of Mr. Merk's journey are given at page 331 of the Proceedings of the Royal Geographical Society for 1886.

cities marks the introduction of wood, which, except in the neighbourhood of some towns, is exceedingly scarce in these regions.

To the north of Jowain the country rapidly assumes a new geographical aspect. Sand is not so conspicuous. The Farah-Rud, Kushk-Rud, and Har-Rud or Adraskand drain from the eastward through gently swelling uplands, whose hard, gravelly surface is traversed by sharp ridges of limestone, which preserve an approximate parallelism and a general trend from N.E. to S.W. These rocky, steep, and deeply serrated ridges are seen on a closer approach to be crossed transversely by numerous open and easy *kotals*. It is the rivers rather than the hills which form the chief physical obstacles, for though the amount of melted snow brought down by them into Seistan is practically inconsiderable, they are all just as liable to violent floods as if they were mountain torrents.

The valley of the Hari-Rud westwards from Herat is separated from the basin of the Helmand by a low water-shed, and is very partially cultivated, notwithstanding that the canal system appears ample and that the villages are packed quite close together. At Kuhsan the English and Indian sections of the Commission met for the first time. Six miles above is the Tirpul bridge, the main connecting link in times of flood between Western Afghanistan and Persia. Up to Kaman-i-Bihisht (about 30 miles below Kuhsan) there is usually an excellent road alongside of the Hari-Rud, but at that point the river commences to flow through a series of magnificent gorges or defiles which it has cut for itself through the mountains, and it cannot be approached till it emerges into a contracted but beautiful valley south of Zulfikar.

Throughout the lower valley of the Hari-Rud the effects of the devastating ravages of the Turkomans on its agricultural population were plainly visible, but the impression formed by Colonel Holdich was that even under settled rule no very great extension of cultivation could ever take place.

From Mashhad, the longitude of which was fixed in the summer of 1885, a triangulation series was brought down southwards to Zulfikar, and the survey of the Persian frontier and eastern Khorasan was carried as far west as opportunity admitted. A junction was effected with the Russian surveys north of Mashhad, but no trigonometrical connexion, as their triangulation had not at that time

come so far south; the fertile valleys of the Jam, of Shahr-i-Nao, and of Khaf were surveyed as far west as Turbat-i-Haidri, and subsequently opportunity was found by Captain Gore of extending his triangulation to the south-west of Herat across the great salt plains south of Khaf to the hills about Birjand. Sub-Surveyors Hira Sing and Ata Mahomed were busy plane-tabling over this border during most of the summer and autumn of 1885, and whilst the route triangulation which had been carried out during the march from India was greatly strengthened between Seistan and Herat, a good basis was secured for the final extension of the survey from Birjand *viâ* Kirman to Bandar Abbas on the Persian Gulf. This was finally carried out by Captain Gore, while the rest of the mission was en route from the Oxus to India, across the Hindu Kush.

The plains at the foot of the Paropamisus range are swept by the same fierce north-west blasts that dry up and almost devastate Badghiz. During the heavy rainfalls in March and April the hills are denuded and a large detritus of mud and sliding rock is spread out, fan-shaped, across the plain below. Occasionally in the course of a few hours the dry beds of watercourses become living mud torrents, with results that were disastrous to the British party. The physical effect of this is to diminish the relative heights of hill and plain, to round off prominent spurs, and gradually flatten the ridge where no central backbone of hard rock exists, rendering it less formidable as a natural barrier. Over the whole line, indeed, of the western Paropamisan system, including its smaller collateral branches, and even the Band-i-Turkestan, which may be called a distinct range, Colonel Holdich says that there is no pass over which a horse cannot be ridden.

The Paropamisus is the name given to the range which bounds the Hari-Rud valley on the north as far west as Kaman-i-Bihisht. Here it is only about 2,000 feet in height, but at Chashma Sabz it assumes a more distinct form with one easily recognisable central water-shed, and from thence eastward past Herat to the north of the Korokh valley it gradually gains in altitude till it attains a height of nearly 11,000 feet above sea-level. The surface soil consists of reddish clay and sand beds, with outcrops of trap and limestone rocks, affording a plentiful growth of grass and brilliant flowers during the summer. Between the western boundary and the Zarmast pass north-east of Herat, at the head of the Korokh valley, there are 11 well-known passes, besides minor tracks, all of which

converge towards Pul-i-Khisti at the confluence of the Murghab and Kushk rivers.

North of the Paropamisus, between the Hari-Rud and Murghab, is the great broken plain of Badghiz, occupied at present by the Jamshidi and Hazara sections of the Chahar Aimak. On either side of the Chingurak range, which occupies a central position, is a multiplicity of rounded hill tops, a sea of sand waves, of which the materials, according to Mr. Griesbach, are due partly to the accumulation of ages of sand drift borne by the almost perpetual north-west wind, and partly to denudation of the mountain slopes. Water is scarce and unequally distributed, but it might probably be obtained without much difficulty from wells. Evidences are not wanting that Badghiz was once a fairly well populated and cultivated region. About Gulran especially there are the partially sand-covered remains of old towns of considerable magnitude, and of a system of *karez* irrigation that covered all the plain between Gulran and the hills. It is only the long continuance of years of misrule and its position in being so open to raids that have transformed Badghiz from a flourishing district into a grass wilderness, the home of the wild ass, of gigantic boars, of innumerable herds of deer, and even of tigers. Eastward of the Murghab river the great central chain of the Paropamisan mountain system increases in altitude from west to east, and the mountain torrents rushing northwards with increased force have cut deeper into the *loess* formation of the *chol* sand drifts. The latter becomes more complicated in feature and difficult to traverse, but it still possesses the same characteristic of being a magnificent grass country, and the evidences of recent occupation and of cultivation are more abundant and fresher. An exceedingly small percentage of the Badghiz district is under cultivation. First a narrow strip bordering the main streams is made tolerably certain of its water supply by a very complete system of canals, beyond a small amount of cultivation which is at a level above irrigation and dependent on rainfall. The valleys are cut up by reedy swamps which in many places occupy nearly the whole of their width, while the supply of water from the rivers (especially in the case of the Kashan) is uncertain.

The loess deposits forming the chol east of the Murghab preserve the same general characteristics throughout the Maimana and Andkhui districts. The irregular mountain tract between the Band-i-Turkestan, which bounds the Maimana district on the south, and the Safed Koh range, which separates it from the Hari-Rud

valley, is drained by the Upper Murghab, and this wild tract, inhabited by the most lawless tribe of the Chahar Aimak (*i.e.*, Firuzkhuis) was entered by Sub-Surveyor Hira Sing in the autumn of 1885. He crossed over from the Korokh valley to the historic old fort of Naratu by the Zarmast pass, and from Naratu made his way to the headquarters of one of the leading Firuzkhui chiefs at Kadis. He then commenced a systematic survey of all the passes crossing the Band-i-Turkestan and connecting Afghan Turkestan with the Hari-Rud valley. The Band-i-Turkestan is a separate mountain system from the Paropamisus, the connecting link between the two on the east being an insignificant water-shed. Its configuration is that of a series of approximately horizontal plateaux, occasionally divided laterally by sheltered valleys, with passes dotted at intervals along the main water-shed at a height of from 8,000 to 9,000 feet above sea-level. As a rule the mountains are thickly covered with forests of juniper on the higher slopes, and an abundant growth of pistachio lower down.

The Firuzkhui country is divided into the following districts:—Kadis, Chakcharan, Sungar, Gharjistan, Kuchar, Bandar, Chaharsada, Mak, and Murghabi (the extreme head of the river). One of the Chakcharan daras called Dara-i-Khargosh or "hare's defile" was graphically described by Arthur Conolly, who passed through it in October 1840.*

* Conolly's full journal appears to have been lost, but extracts are printed in the Calcutta Review, Vol. XV. For 13 miles Conolly and his party journeyed between perpendicular mountains of limestone, the defile running in acute zig-zags, which for the most part were not more than 50 or 60 yards long, and having only breadth enough for the path and for the brook, which the party were continually obliged to cross. The height of the mountains made the horsemen look like pigmies as they filed along their bases in the bed. Conolly remarks: "Take it all in all it is, I " suppose, for its length as difficult a pass as exists. I have seen nothing like it " except some upper portions of the valley of the Ganges, in the Himalaya mountains, " and its impregnability, according to Asiatic notions of warfare, fully warrants the " saying with which Eimaks are said to have answered the threats of kings: " 'Oppress us and we'll flee to the Hare's defile!' "

The Calcutta Reviewer prefixes to his article the title of a work by Mr. E. Sterling, Bengal Civil Service, who journeyed in 1828 from Teheran to India. There is no copy of this book in the India Office Library, but I remember seeing a copy some years ago in the British Museum. I think, however, the author's name was spelt Stirling. Mr. Stirling travelled by the northern route, crossing the Tejend and Murghab, following part of the same road that Vambery and Grodekoff did afterwards. The geographical interest of the journey was slight, but it was curious as the first of a series of journeys destined to open up Afghanistan to western research.

The whole valley of the Upper Murghab is a deep network of such defiles; there are no roads crossing the lines of lateral drainage, and not any continuous road along the river, the Murghab being on the whole a marked exception to the general rule in Afghanistan of the coincidence of direction between main roads and main rivers. The following roads and passes connecting Afghan Turkestan with Herat through the Firuzkhui districts were explored, viz.:—(1) the Kharajangal pass from Chaharshamba to Herat; (2) the group of tracks and passes between the Ao Barik and the Baragan; (3) the Chahardara crossing, which carries the Tailan route over the Murghab into Gharjistan and Chakcharan; (4) the direct route from Maimana and Saripul through Chaharsada, and easternmost of all (5) the Saripul, Chiras, and Daulatyar connexion, followed probably by Ferrier, and surveyed as far south as Chiras by Imam Sharif.

The roads and tracks between Kadis and Bala Murghab, and those from Kadis eastward on the northern slopes of the Safed Koh, have all been explored and reported on. High up on these slopes, at least 5,000 feet above the sea, and about 20 miles east of Kadis, Hira Sing found the remains of a city,* which must once have been large and have possessed considerable local importance; the ruins of an old fort, of stone walls surrounding orchards, and traces of irrigation are still visible. At the head of the Murghab valley the surveying was carried out by Imam Sharif, who found the position of Chiras to be approximately correct, but was unable to identify the Dev Hissar of Ferrier. He found, however, a city,† called the Shahr-i-Wairan (or deserted city), not far from Chiras, situated in a green plain, bounded by glittering white cliffs on the north and by the long straight slopes from the crest of the cliffs overhanging the Askarab on the south. The city must have been of some magnitude, and such buildings as remain are of sun-dried brick. There are no indications of a wall or moat, nothing even suggestive of a canal or *karez*, nothing, in fact, but scattered ruins covering an area of about 1½ square miles. The graveyard was easily recognisable, and its immense size furnished some clue to

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* Major Raverty tells me he thinks this may be identical with Ashizar of Gharjistan, mentioned at pp. 394 and 1071–1072 of his translation of the Tabakat-i-Nasiri.

† This appears to be the same as that mentioned at page 334 of the same work as being in the district of Wajiristan.

the size of the city. Local tradition is, however, quite silent as to the origin and history of this city.

Towards the north the Band-i-Turkistan mountains break up into long, rough, and very irregular spurs, which have a tendency to assume a plateau-like formation, with steep scarped cliffs flanking broad and comparatively level flats. The mountain streams have formed at the foot of these spurs broad alluvial plains, which are rich and fertile and full of flourishing villages. The Kaisar, Almar, and Maimana plains are of this nature. Maimana is an irregular walled town, covering something less than a square mile in extent, most picturesquely situated, with the snowy peaks of the Band-i-Turkistan and Koh-i-Saf to the south and the rolling grass hills of the *chol*. Viewing the city from the Governor's residence in the citadel, its general appearance was not unlike that of Cabul. The bazaar was full of trade, and the mixture of races in its streets was extraordinary.

The hill districts to the east of Maimana, between that place and the Balkh Ao, had been very little known previously. They were surveyed in the spring of 1886 by Imam Sharif, and the results of his observations and mapping form a good record. Shibrghan is a walled town some 500 or 600 yards square, the walls being in a very ruinous condition. The Ersari Turkomans bring in grain and "pushm," which is purchased by the Peshawari bunniahs, and take away in exchange salt, cloth, and other necessaries. Imam Sharif reckoned that even in winter there are not 1,000 permanent inhabitants. Round Saripul, which lies about 35 miles to the south, there is a good deal of cultivation, Saripul and the adjoining district of Sancharak being reckoned two of the richest districts in Afghan Turkistan. They are especially famous for fruit. Saripul itself is a small walled town, with the usual bazaar and citadel. Imam Sharif surveyed a large portion of the intricate and difficult country lying south of Saripul and about the water-parting between the upper Murghab and Oxus tributaries. This region is remarkable for deep gorges similar to those described by Conolly (*vide supra*, p. 178). Cave villages were found in some of the defiles, the dwellings not being entirely excavated, but half natural fissures in the strata and half artificially constructed. Mr. Griesbach, of the Geological Survey, remarks on these extraordinary deep gorges, which are due to erosion. Some of them are scarcely wide enough to admit of an unladen mule being driven through without considerable difficulty.

Many of them are grandly picturesque; below Paoghan the Astarab river flows in a narrow gorge often not more than 30 yards wide, and enclosed by vertical walls of limestone, some 1,500 feet in sheer height above the river bed. Most of the rivers flow from south to north, and hence form transverse valleys through the ranges of Turkistan. They have eroded gorges where they cross anticlinals and formed wider valleys with side streams when on a synclinal.

In the summer of 1885 the necessity of finding some fixed geographical point on the Oxus near that end of the boundary became apparent. The Kuhsan base had been connected with Mashhad by direct triangulation, and the longitude value of Mashhad (determined telegraphically with Tehran) was thus brought down to Kuhsan, while the triangulation itself formed an excellent basis for the commencement of boundary demarcation from any point on the Hari-Rud adjoining the Russian frontier. But it was then known that the boundary would run in a north-easterly direction through the *chol*, a country particularly unfavourable for connected triangulation. Without some reliable check the accuracy of the boundary survey would have been unavoidably open to question. Captain Talbot was therefore deputed to undertake the difficult and dangerous duty of carrying out a series eastward along the Hari-Rud valley, from which series it was hoped that points might be fixed to the southward for the basis of surveys between the Hari-Rud and Zamindawar. He was to push his triangulation eastwards if possible to a junction with points already trigonometrically fixed from India on the Hindu Kush and Koh-i-Baba mountains, within sight of Kabul. He was then to carry it across the great central mountain chain to Bamian, extend northward through Haibak and Ghori to Mazar-i-Sharif and Balkh, and finally carry on westwards till he sighted Kilif on the Oxus and the mountain peaks of Bokhara. *Pari passu* with his triangulation he was to carry out a plane-table reconnaissance embracing all the country he could see, for there was no topographer available for the duty. All this work was successfully accomplished, though not all at once. After pushing forward his triangulation past Herat to Daulatyar with fair success, Major Talbot was hurriedly recalled in August 1885 to help in making arrangements for the defence of Herat. It was not till late in September that the political situation enabled him to retrace his

steps to Daulatyar. The delay was almost fatal to his success, for the winter set in early, and it was only after a constant struggle against snow, rain, mist, and clouds which often defeated him on the summit of some gigantic peak after hours of weary labour lost in climbing, that he at last emerged into the plains of Afghan Turkistan, with his connexion with the Hari-Rud weak but not entirely broken. It was not till the following spring that the series between Balkh and Andkhui was finally completed; when completed it was met by a series that had been run by Major Holdich and Captain Gore through the *chol* between Zulfikar and Andkhui. Thus a final system was evolved which covered the whole of Afghan Turkistan and wild country south of the Hari-Rud valley as far as the basin of the Helmund with a network of triangulations which included several hundreds of well-fixed points.

Captain Talbot found that the Hari-Rud rises about 34° 30′ N. lat., and 67° 0′ E. long., and flows for some 70 or 80 miles to Daulatyar almost due west, and not as hitherto shown on the maps. As far as Daulatyar it is known as the Ab-i-Sar-i-jangal, and at that point it was a broad but easily fordable stream. At the head of the valley it is probably about 12,000 feet in general altitude above sea-level, but gradually drops to about 5,000 feet opposite Obeh. There are, however, occasional peaks on it, one of which runs to 11,000 feet at a distance of about 20 miles of Obeh. The mountain ridge is singularly straight, with slopes bare of trees but an abundant water supply, and a luxuriant growth of grass and wild flowers in every *tagao* or stream bed. Some of these narrow valleys are well wooded with willow trees and occasionally hawthorn. From its source to Obeh the course of the Hari-Rud is about 240 miles in length, and above Dahana Doab it includes a catchment area of about 8,000 square miles.

About the time that Captain Talbot started for his triangulation towards Bamian and Kabul, Sub-Surveyor Imam Sharif was deputed to undertake a complete exploration and a survey, as far as possible, of the hitherto little known districts which lie to the east of the road connecting Farah and Herat and south of the Hari-Rud valley. Not much was on record respecting this tract, except what was to be gathered from Ferrier's somewhat doubtful account. It was known to be inhabited by the Taimani section of the Chahar Aimak, but the position of Taiwara, the capital of the Taimani country, was

uncertain, as well as that of Zerni, mentioned by Ferrier. In the first instance, Imam Sharif had to base his surveys on a measured traverse, but when Captain Talbot's triangulation had extended over the country his traverses were reduced to an agreement with the points fixed by triangulation. Imam Sharif passed the historical peak of Chalapdalan, the true name of which is Chahil Abdal. Round it are inaccessible cliffs, and the peak itself, described by Ferrier as one of the highest mountains in the world (!) attains the height of 12,000 feet. Its position has now been accurately fixed, as it forms one of Captain Talbot's trigonometrical points. It is said to be the "Takht" of Zohak-i-Maran, the snake-bearing governor of these provinces in the days of Cyrus, and it was from here that he built the massive walls and towers of those old forts which surround Taiwara and border the way to Ghur.* The walls of these strongholds are built of sun-dried brick and mud, but they still stand so straight and square on their massive basements (from 15 to 20 feet wide) as to convey the impression of being newly built. Taiwara is situated at the junction of two considerable streams, the Chahardar and the Ghur (or Gaur in existing maps). The Taiwara fort is square in form, and comparatively new; it contains the residence of the Khan. At Yakhan Pain, south-west of Taiwari, old massive forts and remarkably extensive ruins of an ancient city were observed. The Chiling Shahi Mardan hill to the east is of some interest, as there is a remarkably pointed peak with rough hewn steps leading to the summit, whereon Ali is said to have fasted for 40 days, and which is now a shrine of great sanctity. The valley of the Nili (one of the tributaries of the Ghur) is well cultivated and full of trees, which is most unusual in this timberless country. The trees are not indigenous, being mostly apricot trees. Nili and Zerni fort are only three or four miles apart, and from the Hari-Rud to that fort the people are all Taimanis, and showed themselves civil and hospitable to strangers.

While engaged in his explorations in the Firuzkhui country, and about 15 miles from Daulatyar, Imam Sharif was robbed during the night of nearly all he possessed; his theodolite was wrecked, his aneroid broken and thrown into a stream, his records all carried off, including a long series of barometric obervations and his notes on the Taimani country and its history. By good luck his plane-table

* *See* Raverty's translation of the Tabakat-i-Nasiri, page 331, where reference is made to the *Kasrs* or forts built by Abbas of Ghur.

was under his pillow and his complete sheet of survey rolled up in his bed, and these being saved he was enabled to continue his survey.

The Khan of Taiwari stated that there were at least 15,000 inhabitants in the Taimani country, which he described as a poor country with no fruit, and in great part deserted during the winter, when the people migrate to Sabzawar, the Helmand, or more genial climates. Snow lies deep in winter. The cultivation consists entirely of wheat, except in the Ghur valley, where a patch or two of melons exists.

The people are not absolutely poor; they own large herds of sheep and goats, and trade in otter skins and wool with merchants who come from Herat and Candahar. The Taimanis also own a few cattle, and are invariably mounted, every man owning his horse. They resemble the Jamshidis more than the Hazaras or Firuzkhuis, and are exceedingly hospitable to travellers.

Late in the autumn of 1885 Sub-Surveyor Imam Sharif, having completed the survey of a great portion of the Taimani country, started to push his previous survey to a junction with those already completed between Farah and Herat on the west, and to extend his work as far south as he could. A connexion was fortunately established with previous topography which had been completed from Girishk, and together with the route survey made by his brother, Yusuf Sharif, who was deputed to join the mission during the winter of 1885–86, he secured a very complete knowledge of many hitherto unknown routes and passes between Herat and Kandahar, and completed the map of Western Afghanistan from its extreme northern portion to the confines of the Helmund valley. He was, however, unable to penetrate into Zamindawar, which still remains a hot-bed of disaffection to the Amir, and of fanatical hatred to all foreigners. He explored the Adraskand river and the Sabzawar valley thoroughly, and visited Farah, adding much information to that previously existing about the Farah district. He was everywhere well received and civilly treated.

Altogether, Imam Sharif was enabled to produce a fairly accurate map of a large area of country lying south of the Hari-Rud, about which exceedingly little was known, and which is of most special importance as bearing on the communications between Kandahar and Herat. That little is chiefly derived from Ferrier's accounts of his journeys, which, however, proved to be erroneous in several

respects. Previously to Imam Sharif's explorations the exact localities occupied by the Moghuls were unknown. There are about 800 families living in Nili, Zerni, and Ghur Muskhan, who speak a language strongly allied to Turki, and claim to have been brought into the country by Chingiz Khan.

The great plains of Afghan Turkestan lying south of the Oxus, between Andkhui and Badakhshan, as well as the river itself, were thoroughly reconnoitred. According to Griesbach, the vast deposits of clays, gravel, and loose sandstone which form these plains have been in process of accumulation since the pliocene era, huge fans have been spread out at the points where the present rivers, the Kaisar, Saripul, Khulm, and Balkh Ao, enter the plains, the finer deposits being carried to the furthest limits of the fans. Over this base in belts of various widths are thick waves of blown sand, wind-borne from the north-west, and occasionally spread out so as to completely cover the fluviatile deposits below. Griesbach suggests that the great swell in the plain in which the southern tributaries lose themselves represents an anticlinal now in course of formation, and that the river is, as it were, flowing along the crest of a mountain range also in course of formation.

None of the tributaries of the Oxus basin west of Kunduz draining from the mountain districts on the south find their way at any season of the year to the river. During the flood season in spring they often spill over their ordinary channels and form large swamps and lagoons. Enormous masses of detritus and vegetable matter are brought down from the channels of the hill streams, which are thoroughly cleaned out of the year's vegetable growth, and the sweepings of the hill-sides of the Band-i-Turkistan, of the Hazarajat, and the Turkistan high lands generally. The Oxus itself brings down large quantities of vegetable matter, and during the summer months it becomes a rolling chocolate-coloured sea, bearing even large trees on its tide. Similarly there is a vast amount of serviceable timber stranded along the lower course of the Tejend.

To the north and north-west of Andkhui is a vast area of open plain which is not sheer desert but consists of *chol* formation modified by aërial deposit and converted into gently swelling downs and sandhills from which vegetation is never entirely absent. From time immemorial wells have been dug, yet in spite of their number the supply of drinkable water is exceedingly scanty. The extremes of temperature are described as something terrific; the north-west

winter storms darken the atmosphere in the course of a few minutes and freeze the life-blood of men exposed to them; in summer the heat is almost more intolerable, and it is impossible to cross these regions without special precautions. Two very distinctly marked and isolated natural hills called Kara Tapa Khurd and Kara Tapa Kalan formed two trigonometrical stations of great importance owing to the unvarying features of the surrounding country.

The Oxus at Khamiab is a majestic river, comparable to the Indus below Dera Ismail Khan or the Brahmaputra in Assam. The neighbouring settlements of the Ersaris offer a most marked contrast with the usual Turkoman villages; the houses are well built and well kept, the roads are well defined, the irrigation channels kept clear and clean, substantial bridges cross the canals, and the whole atmosphere of the Khwaja Salor district is one of prosperity. The Oxus continually carries away portions of its banks, and the positions of its ferries and roads have materially shifted from time to time, the principal ferry now being at Kilif, where the river narrows to about 400 yards. A similar crossing is at Termez, some 30 miles above Kilif, running between hard rocky banks, which will protect its channel from further alteration through future ages. Through the Ersari country wells were certainly more plentiful, and the existence of old irrigation channels for 11 miles beyond Kilif points to a time when this part of Afghan Turkistan must have been as well populated as the great Balkh plain. The devastation effected by that destroying angel of Central Asia, Chingiz Khan, who razed Nishapur, Merv, Balkh, and Herat (once a large city of four times its present size), doubtless changed the fair face of the country into a wilderness in his time, and the modern raids of the Kara Turkomans, combined with the tendency of the Uzbeg people to emigrate in order to avoid a tyrannous rule, have kept much of the land unproductive. As a rule the Oxus flows through many channels which shift and alter just as they do in other large rivers not confined to a single bed by hard rocky banks.

The ferry at Kilif has been often described, and is worked (as it was 50 years ago) by a system of attaching horses to large clumsily built boats and swimming them across stream. The Shor Tapa district, which extends from Kilif for 36 miles to Chobash, is described by Captain Peacocke as consisting of six smaller districts, each of which has its own canal from the river lined on both banks with the usual orchards, houses, enclosures, and mulberry plantations, and is occupied by some 6,000 families of Ersari Turkomans. At

Termez there are the ruins of gigantic brick buildings, including a large-domed ziarat, said to contain two inscriptions, one on marble and the other on a silver plate, recording three occasions on which the place was sacked, once by Alexander the Great. Beyond Chobash (with the exception of the small new settlement of Kuldar) to the mouth of the Kunduz river, 140 miles above Kilif, there are no inhabitants, and the back water, swamps, and jungles in which tigers and large deer are found, make it impossible to reach the bank of the stream. Sub-Surveyor Ata Mahomed describes the Oxus as a very large river when seen in flood, rarely if ever less than 1,000 yards wide, with a normal width of about 1,400 yards, while in some places it must be a mile across. The winter volume of water may be taken at one half the summer flood, and the average current varies from 2½ to 5 miles. In the neighbourhood of Shahk in Kabadian, not far from the mouth of the Kunduz river, Greek coins and ornaments are found in large quantities. Striking southwards from the Oxus towards any of the great cities of Balkh, Mazar-i-Sharif, or Tashkurghan, there is always the same desolate waste of partially sand-covered country to be crossed before there occurs the first appearance of cultivation. Here and there, on the southern edge of the sand belt, are vast piles of ruins covering many square miles of country. Khanabad, Siahgird, and Khulm are perhaps the most striking of these.

To the traveller approaching Balkh from the west there is nothing very striking about the "Mother of Cities," nor to indicate its former greatness among the cities of Central Asia. One enters through a gap in the walls which was once a gateway; inside the outer wall are ruins and mounds of mud and brick on either hand standing so close as hardly to admit of the roadway; the covered bazaar contains about 400 shops, and gardens and orchards cover a fair extent of ground. But the visible ruins are not very ancient, and most of the past generations of departed cities probably lies beneath the grass-covered mounds which surround the walls rather than below the site. The most striking feature is the extent of the shattered old fort called the Bala Hissar, which overlooks the city and was once its great stronghold.

The high open road between Balkh and Mazar-i-Sharif passes through a cultivated plain, across which the blue domes of the mosque at Mazar are very striking objects as they glitter in the sun above dense masses of surrounding trees. About four miles

before reaching the outskirts of Mazar-i-Sharif the direct road runs through the new cantonment of Takht-i-pul, a place of considerable strength, with a ditch and double wall pierced by massive gateways. It is said to have been the residence of the first governor of Afghan Turkistan before Mazar was made the seat of government.

The Mazar of the present day is a very different place to that described by Ferrier. Its gardens and orchards cover an area of about four square miles, and the citadel and residence of the governor as well as the far-famed mosque, the burial place of Ali, are all in a state of flourishing repair, which is lamentably deficient in most Turkestan cities. It is inhabited now chiefly by Afghans, the Uzbeg population being rather on the decrease. As a trade centre it is inferior to Tashkurghan, which occupies a better geographical position, but its climate is said to be far healthier, and as the seat of government in Afghan Turkistan it certainly ranks first among the cities north of the Hindu Kush.

Between Mazar-i-Sharif and Tashkurghan the road passes over an open plain, on the right of which are imposing cliffs presenting a long uninterrupted line of straight wall rising sheer above the plain to a height of from 4,000 to 5,000 feet, and forming the northern edge of a vast plateau extending up to the Hindu Kush.

Tashkurgan is about 35 miles nearly due east of Mazar, and about a mile and a half from the gates of a magnificent gorge barely 40 feet wide at one point, with sheer cliffs on either hand thousands of feet high, which leads towards Haibak. Tashkurghan is a large and exceedingly picturesque town clustering round the slopes of a sandstone hill, crowned by a fort and citadel. Its busy bazaar is the great trade centre of the country.

The conformation of the great plateau region, which embraces the basins of the Band-i-Amir (or Balkh Ao), the Dara Yusuf, the Khulm, and the Kunduz, is difficult to describe from its extreme irregularity. North and east of the Balkh Ao there is a raised plateau rising gently northwards and culminating in rounded knolls, the whole region, except where intersected by the Dara Yusuf, being apparently uninhabited. Captain Talbot visited the head waters of the Balkh Ao, which are dammed by a succession of small lakelets, the formation of which is ascribed to Ali. The course of the Dara

Yusuf* was surveyed by Sub-Surveyor Ata Mahomed, and is similar in most characteristics to the Balkh Ao.

Haibak† is a picturesque place with a small hill fort overlooking the bazaar and the overcrowded little town. Round about the plain are the sharp square-cut cliffs which are ever the distinguishing feature of all the plateau, and a mile to the south, across the well cultivated fields, is the mouth of the well known and picturesque Dara-i-Zindan (mentioned by Burnes) leading to Bamian. Neat white-walled villages overlooking the rippling stream, well built bridges, closely-set orchards, and meadows with grass lawns sloping to the river, and above all the crags and many-coloured walls of the precipitous cliffs on either side combined to form a picture of which the beauty was doubly impressive to the eyes of officers accustomed to the sterile wastes of Turkistan. The Buddhist ruins and rock-cut stupa called Takht-i-Rustam in the neighbourhood of Haibak were examined by Captain Talbot, who has written an account of them as well as of the better known Bamian remains.

The Ab-i-Surkh, as the upper valley of the Kunduz is called, is not distinguished by such remarkable defiles and gorges as that in the Khulm and Balkh Ao. South and east of it one comes upon the Hindu Kush system, and every pass to the southward crosses a succession of spurs of that great range. The local nomenclature makes the Hindu Kush terminate at the head of the Ghorband valley, east of Bamian, so that the Irak pass to Bamian from Kabul does not cross the true Hindu Kush, but a connecting water-shed between it and the Koh-i-Baba.

With regard to the Hindu Kush range, Colonel Holdich notices that the same feature prevails as is observable in the case of the Himalayas, *i.e.*, that the central or main water-shed is not defined by the most prominent peaks, which rise high above it from the ridges of gigantic lateral spurs. There is, too, a remarkable similarity in the general altitude and appearance of these granite giants, and at a distance they are difficult to recognise distinctively. The same may be said of the mountain mass of the Koh-i-Baba,

* This route is most important and leads past the remarkable hill fort of Valishan, which was besieged by the Mughals, as described in Raverty's Tabakat-i-Nasiri, p. 1023. Raverty calls it Walkh and is inclined to identify it with Zuhak in the Bamian valley, but Sir H. Rawlinson shows it is more probably the Wuleeshan of Mir Izzut Ollah and the Valej or Val-valej of the old geographers.

† Curiously enough, Haibak is omitted from the late Sir Charles Macgregor's great work, the Gazetteer of Central Asia (Afghanistan).

whose crowd of irregular snowy peaks are equally hard to tell apart. A very great difficulty was thus presented to the direct connexion by triangulation of the previous surveys executed during the Afghan campaign from the Kabul side and those now drawing to a close of Afghan Turkestan. The longitude values in the latter region had been brought over many leagues of desert and mountain from Mashhad to the Hindu Kush, while the values about Kabul were well determined and in direct connexion with India. The latitude values depended on constant astronomical observations, which might fairly be expected to be correct to one or two seconds, as they were checked within certain limits by the results of triangulation. Fortunately, right on the backbone of the main water-shed of the Hindu Kush, a peak was at last discovered whence Colonel Holdich was enabled to recognise the well-known landmarks of the Kabul campaign, whilst due north were one or two granite pinnacles belonging to the Turkestan Series. Thus the two systems of triangulation were finally and successfully united with a general agreement that was highly satisfactory, considering the enormous area traversed, and highly creditable to Colonel Holdich and his colleagues.

The next piece of work was the survey of the Hindu Kush and the routes and passes connecting Afghan Turkistan with Kohistan and Kabul. These surveys were carried out by Colonel Holdich, Captains Peacocke, Talbot, and Maitland, and Sub-Surveyors Yusuf Sharif, Ata Mahomed, and Hira Sing, and on completion of the work all assembled at Charikar. Yusuf Sharif ascended some peaks near Khawak and made some additions to the existing knowledge of the surrounding mountain region. The main water-shed of the Hindu Kush preserves a singular uniformity of level, while the gigantic spurs which intersect Badakhshan and Kafiristan, and which rise almost to the dignity of separate ranges, are repeated along the entire length of the Hindu Kush on the north as well as on the south, enclosing valleys similar to the Ghorband and Panjshir. But the physical characteristics of the northern offshoots are distinctly different from those of the south, and might well belong to a different system and climate. Rough barren walls and ridges of limestone and granite tower above the narrow valleys on either hand, splintering at their summits into sharp aiguilles streaked with snow even in the summer months, and constantly hurling down avalanches of rocks to block the narrow green riband that borders the mountain streams.

As the road winds up amongst them and the flattened slopes of the main water-shed are gradually approached, their sterility and barrenness recall that of the Tibetan passes. On the southern side it is far different. Every valley leading down from the snow-bound rivulets and lakelets of the broad water-shed into the valley of the Ghorband is a picture of fertile beauty, surpassing even the most favoured spots of Alpine scenery. There were battlemented turrets of ancient strongholds, perched insecurely on red clay and sandstone cliffs, amid an endless succession of terraced hill sides, vineyards, and yellow maize fields; these again were backed by the deep purple of the hills and broken into a cascade of colour by the marvellous tints of autumn which spread over the surrounding trees. To the British officers, Kabul and its well-remembered surroundings marked the end of their geographical labours.

In connexion with the work of the Afghan Boundary Commission some important explorations of the Pamirs and Upper Oxus valley were carried out by Mr. Ney Elias, C.I.E., of the Foreign Department of the Government of India, already known for his adventurous journey across Mongolia in 1872–73, for which he received the gold medal of the Royal Geographical Society.

Mr. Elias started in September 1885 from Yarkand to cross over by way of the Pamirs to Shignan. He left the plains at the frontier village of Ighiz Yar, and took what is known as the Karatash route, *i.e.*, over a pass of that name (about 14,200 feet in height) which leads over a range forming the water-parting between the Guz river and the streams flowing to Yangi Hissar, &c. The Guz was found to rise in snow fields to the south of the pass and then to flow on between the great peak measured by Captain Trotter, by theodolite angles from Kashgar, Yangi Hissar, &c., and another great isolated peak to which Mr. Elias had to give the name of Tagharma,* from the Pamir region at its base. The Kirghiz nomads have no particular name for either; but the Tagharma peak is known over all those regions. It is probably the one seen by Kostenko from near Great Karakul and called by him Mustagh Ata. Close to the foot of the great Tagharma cone, and only three or four miles north of the Guz, lies Little Karakul, through which flows a stream into the Guz. From Little Karakul Mr. Elias proceeded to Rangkul, and passed the "Lamp Rock" (*see* Sir H. Rawlinson's

* Conf. Ezekiel, xxvii., 14 (Lamentation for Tyrus), "They of the house of Togarmah traded in thy fairs with horses and horsemen and mules."

paper*) to the Aksu or Murghabi river, which he crossed on the way to the Alichur Pamir, after crossing the Neza Tash pass (about 14,000 feet). Proceeding down the Alichur valley Mr. Elias passed south of the Sasik and other small kuls in the neighbourhood, and crossed the Kohitezek pass (about 14,000) into one of the head streams of the Gund river. The Gund valley was then followed down to its junction with the Panjah, nearly opposite Bar Panjah fort. So far the journey had proved that the Aksu did not discharge down the Gund valley as some maps represented, but as Mr. Elias had to investigate this Aksu question (he had found it impossible to follow it down from where he crossed it near Rangkul) he went on at once from Bar Panjah (4th November) to ascend it as far as possible from Kila Wámar. The track was found impassable for anything like a caravan, or even a loaded pony. It was chiefly climbing over pathways built along the side of the cliffs, of bits of wood, willow twigs, &c. Mr. Elias succeeded in reaching as far as the confluence of the Kudara (which turned out to lie much further north than supposed) and then returned to Wámar. From thence he descended the Panjah to the frontier of Darwáz, and then returned to Bar Panjah. After a short stay there he ascended the Panjah to Ishkashim, making an excursion to the Shiva lake en route. This lake was an interesting spot. It turned out to be a high mountain tarn (not a flat-bottomed lake like the Pamir lakes) with an underground outlet into the Darmárokht stream, which carried its waters "cascading" down into the Panjah. The height of the lake was 10,300 feet, and that of the Panjah at the confluence about 6,800, the bee-line distance between the two being a little over six miles.

At Ishkashim, early in December, he came upon Lieutenant Wood's route, and the work of several native explorers, so he there concluded

* Proceedings of the R. Geographical Society for 1887, p. 69. Sir Henry Rawlinson's short but interesting paper identifies this central Pamir track (which had also been mentioned by Major Trotter in the appendix to Sir D. Forsyth's Yarkand Mission Report, p. 457, Route XXVII.) as the famous trade route of antiquity, by which the caravans of Rome passed from Bactria along the "Vallis Comedarum" to the equally famous Stone Tower on the border of Chinese territory. Sir Henry proves that it is in all probability the route followed by Hwen Thsang, and that the Dragon lake, the holiest spot in the Buddhist cosmogony, can be none other than the Rang-Kul lake, where the mythical legend of a dragon with a large luminous diamond set in its forehead is still believed in by the Kirghiz inhabitants. Sir Henry also points out that Mr. Ney Elias discovered traces on the Little Kara Kul and the Yeshil Kul of the passage of the Chinese troops who in 1759 pursued the fugitive Khojas as far as the latter point in their flight to Badakhshan.

his route survey. He had carried it on all the way from Ighiz Yar, and it came to over 600* miles between the two. Points were fixed as usual by an observation, and altitudes by boiling-point measurements based upon Yarkand. In the map submitted by him to Government on his return to India the altitudes were all given about 250 or 300 feet too low. It was made up before he had time to send the boiling-point thermometers to Kew to be retested. After that was done he computed all the altitudes afresh with the new corrections and found the above general error.

From Ishkashim Mr. Elias proceeded to Faizabad and stayed there till the beginning of January. It was too late in the year for travelling at high altitudes, and all Mr. Elias was able to do was to go on to Khanabad, near Kunduz, on a visit to the governor of the province, and thence make an excursion to the confluence of the Kokcha and Panjah during an interval of open weather, when a little new geography was got in. Faizabad was found to be a small trading place of about 4,000 inhabitants, mostly Tajiks, and Khanabad a somewhat smaller town, with chiefly a Turki population. Kunduz is now in ruins and almost uninhabited, and Khanabad has taken its place.

From Khanabad, early in February, Mr. Elias was obliged to travel down to the Turkoman country to join the Afghan Boundary Commission, then near Maruchak on the Murghab, and was only able to leave them towards the end of April to return to Badakhshan. However, no geographical work was done on Mr. Elias's return as he was recalled to India *viâ* Chitral and Gilgit, arriving in Kashmir eventually towards the end of September 1886.

The zoological investigations during the Afghan Boundary Commission fell to the lot of Dr. J. E. T. Aitchison, C.I.E., F.R.S., F.L.S., who was appointed naturalist, and had thus to undertake general duties in addition to his more special calling of botanist.† Captain C. E. Yate and Lieutenant Rawlins and other members of the mission rendered assistance in the supply of specimens, but the absence of regular collectors was a drawback, the Afghans being useless in this respect. Dr. Aitchison's collections comprised 290

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* Not 360 miles, as erroneously printed in the R. G. S. paper, p. 69, of 1887.

† Transactions of the Linnean Society of London, 2nd series Zoology, Vol. V., Part 3. "The Zoology of the Afghan Delimitation Commission," by J. E. T. Aitchison, M.D., C.I.E., F.R.S., F.L.S., London, 1889 (plates and two maps).

See also a paper by Dr. J. Scully on the mammals and birds collected by Captain C. E. Yate, C.S.I., of the Afghan Boundary Commission (J. A. S. B., lvi. pt. ii., p. 68, 1887).

species, of which 32 were new, belonging to 210 genera. One of the most interesting was the *Ellobius fuscicapillus*, a curious bull-dog headed mole-like rat with enormous incisor teeth. The whole of the Badghiz east of the Hari-Rud was in many places perforated like a sponge from the burrowing of this and other rodents, making it very unsafe to ride over. Another point of importance is the extension of the geographical range of *Felis tigris* in Afghanistan as far east and north as Bala-murghab, and that of the hunting leopard (*Felis jubata*) to the valley of the Herirud. A specimen of each is in the Zoological Society's Gardens in London.

The botanical researches during the progress of the Commission also fell to the care of Dr. Aitchison, and his observations thereon are likewise recorded in the Transactions of the Linnean Society.* He divides the country which was traversed into seven natural sections or regions, as represented by its physical features, viz.: Northern Baluchistan; the valley of the Helmand, from Hadj-ali to the Hamun of the Helmand river; the basin of the Harut, from the Hamun of the Helmand to Pahir; the valley of the Hari Rud; the Badghiz district; Mount Do-shakh and Khorasan. Dr. Aitchison's generalizations are that the flora of North-western Afghanistan differs much from the typical flora of Eastern Afghanistan, so graphically described by Hooker and Thompson in their introductory essay to the "Flora Indica," and that this difference is due to climatic conditions. The winter is much more severe and of longer duration; in spring the persistence of damp and cold is also more prolonged; while the summer, though short, is intensely hot during the months of July and August. There is no mountain range to the north, moreover, to afford shelter from the continuous blasts of winter cold and hot dry air of summer; so with such climatic conditions, cultivation below an altitude of 3,500 feet is impossible without the aid of irrigation or under the mitigatory influence of a river. Dr. Aitchison's collection consisted of oriental flora, with a considerable admixture of Siberian and Central Asiatic types; there are also a few Western Himalayan or Tibetan plants, and a very limited number common to the Punjab and Sind regions.

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* 2nd Ser. Botany, Vol. III., Part 1, April 1888.

VIII.

TIDAL AND LEVELLING OBSERVATIONS.

The systematic record of tidal observations in India may be said to date from the 4th July 1877, when an important Resolution on the subject was passed by the Government of India. The advantages of such observations were pointed out in the Resolution to be mainly the following :—

(1.) They enable standards to be fixed for the purposes of survey.

(2.) They afford data for the calculation of the rise and fall of the tides, and thus subserve the purposes of navigation.

(3.) They are of scientific interest apart from their practical usefulness.

The first two of the above were considered by the Government of India to be of strictly local bearing, an accurate survey of a port being essential to the safety of the shipping frequenting it, and correct tide-tables necessary for the convenience of navigators and engineering purposes within the port itself. It was therefore laid down that every port where a tidal gauge was set up should pay for its establishment and maintenance from port funds. The third object, the scientific results to be expected from the record, would be sufficiently provided for by the appointment by the Government of India of one of its own officers to supervise and control the local observations, and to arrange for their utilisation.

The general superintendence and control of the tidal observations (which included a continuous registration of the barometric pressure and of the velocity and direction of the wind taken by self-recording instruments) were entrusted to Captain A. W. Baird, R.E., Deputy Superintendent, Great Trigonometrical Survey of India, who had

already for some years past been engaged upon tidal observations in the Gulf of Cutch and on their reduction in England.

Inquiries were at once set on foot to ascertain the most suitable ports for tidal stations. The necessary conditions were, firstly, a site immediately over or close to the sea, where the depth was not less than from 10 to 15 feet at lowest tides; secondly, the presence of a port officer to exercise a general supervision over the operations and correct the clocks of the several self-registering instruments whenever necessary, either by direct determination of time or by getting the true time from the nearest telegraph office; thirdly, the feasibility of periodical inspection of the instruments at intervals of not less than six months generally, and more frequently when there might be no superintending officer resident on the spot.

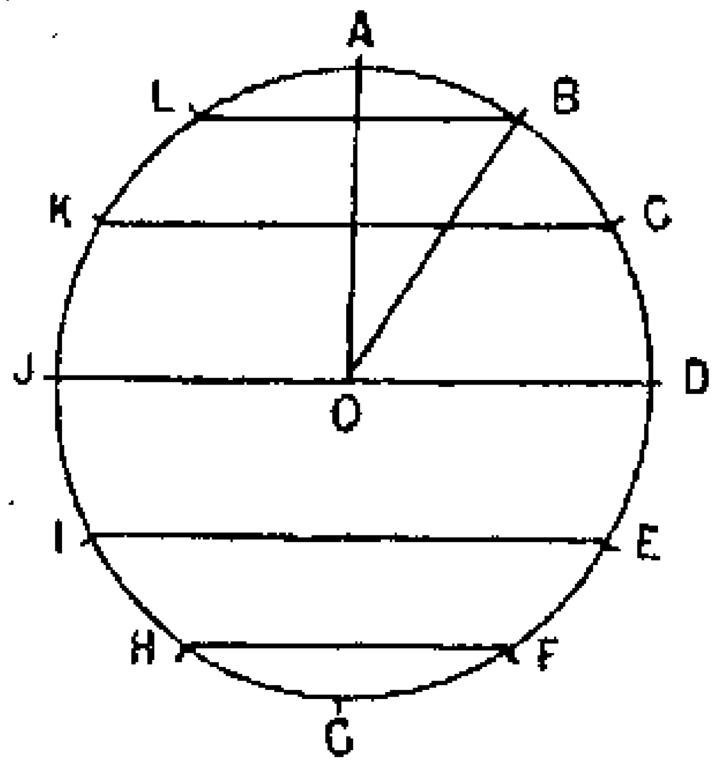
During the following year Captain Baird visited Bombay, Karachi, Karwar, Aden, Beypur, Paumben, Madras, and Vizagapatam, making due arrangements at each port. A man was placed in charge of the instruments in each place, and taught how to manipulate them; he was also taught to read the graphic delineations of tidal height, and to enter the value for each hour in a tabular report which was sent off to Poona daily.

The barrels of the tidal gauges are five feet in length, and thus capable of registering on the scale of nature all tides of which the amplitudes between extreme high and low water do not exceed five feet. For tides of greater amplitude a gear of wheels is supplied to each instrument, enabling the scale to be varied.

The analysis of tidal observations is a matter of much complexity, and from the outset Colonel Walker determined to adopt the procedure recommended by the Tidal Committee of the British Association for the investigation of the tidal constituents, and to employ Mr. Edward Roberts, F.R.A.S., of the Nautical Almanac Office,—who, under Sir William Thomson's supervision, had reduced and analyzed the tidal observations placed at the disposal of the British Association for the advancement of Science—in working out the yearly tables of tidal prediction from the values of the tidal constituents with his tide-predicting machine.

In the system of analysis adopted by the Tidal Committee of the British Association, the successive heights of the tide for each hour at each port are grouped in a large number of combinations, so that the exact effect of each grouping is ascertained with great precision. The following explanation may serve to elucidate the

process pursued. If the height attained at any tide be marked upon a wharf wall, as at A in the annexed diagram, and also the point of lowest depression as at G, and a circle drawn through these two extreme points, then, roughly, the heights at equal successive times may be found by dividing the circumference of the circle into equal parts, as at B, C, D, &c., the fall and succeeding rise of the water reaching the points thus found in equal times. If now, for simplicity, the tidal heights at each hour of the day be thus grouped together for an entire year,* and the sums and means of the 365 groupings taken, the *mean* value of the effect due to the sun will be obtained. Similarly, another grouping according to mean lunar hours will give the *mean* value due to the moon. These values would represent the values supposing the sun and moon to be always at the same distance from the earth, and also at the same inclination to the horizon. The lunar orbit, however, is far from circular, and in practice it is found that it is necessary to include several other groupings to correct the mean values obtained as above. A smaller number suffices for the solar tide, the earth's orbit approximating much nearer to a circle. Other groupings correct the mean values for the varying inclinations of the sun and moon due to the different declinations or distances from the equator of these bodies. The effects due to rainfall and other meteorological causes are similarly found.



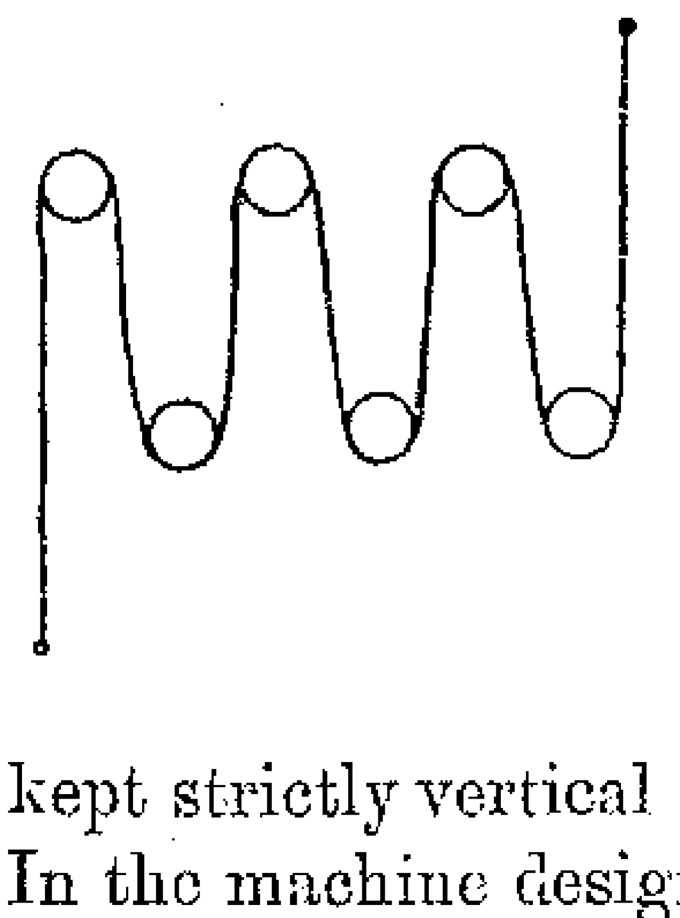
In practice about 25 groupings are made, and some 30 values obtained. The quantities obtained give the value of each tidal constituent in feet (or other measure) and the *time* at which such constituent tide is at its maximum. For simplicity we may assume that the tide traced on the wharf wall is due to only one body, and that the water attains the successive positions indicated by the points A, B, C at each succeeding hour from noon at A to midnight. Then the value of the tide found from the groupings will be the *range* or radius of the circle O A, and an angle such as A O B will give the *time* at which the tide was at its maximum or highest point. The *mean* level of the water will be given by taking the

* For special reasons a period of 369 days 3 hours is generally used, being 25 semilunations.

mean of all the successive heights, and in the figure is represented by J D.

If now it is required to calculate the height of the tide for any port for which the tidal values have been obtained, it will be necessary to find the value of the heights due to the mean sun and the mean moon, and also each of the smaller constituents due to the ellipticity of their orbits, &c. The algebraical sum of these added to the *mean* height will give the height desired.

It will be readily seen that if the number of ports be considerable heights calculated in this manner for, say, each hour of the day for a whole year would involve very great labour and require a considerable staff of calculators. Recourse has consequently been had to mechanical means to effect the desired object. It will be readily understood that if, say, the hand of a clock represented proportionally the value of any one tidal constituent, and it is made to revolve in its proper time, then the successive heights due to the component will be traced by the end of the hand. Similar movements would represent the other tidal constituents, and all that would remain to be effected would be to *combine* all the heights thus traced out. The tide-predicting machine, made by Mr. A. Légé from the designs of Mr. Edward Roberts for the Indian Government, embodies a beautiful and simple means of combination, the suggestion of Mr. Beauchamp Tower, and consists of a very fine and flexible wire fixed at one end and carrying a tracing point at the other. This wire passes successively over and under 20 pullies arranged in two rows of movements above and under each other. Each pulley is made to revolve relatively to the others in its own proper time, and is capable of being thrown out from its centre to the range of the constituent it represents.



The *free* or tracing end of the wire will thus represent the height due to the whole of the pullies. To avoid the error due to the wire being thrown out of the vertical by the revolution of the pulley it is carried on a parallel slide (designed by Sir William Thomson), whereby the wire is kept strictly vertical under all the varying positions of the pullies.

In the machine designed for the Indian Government Mr. Roberts has included no less than 24 tidal constituents, which, for most

ports, include all that produce any sensible effect, and he has been most successful in finding numbers for the wheels in the gear-work which represent relatively the periods of each of the constituent tides. The machine can be run for a period representing a whole year, practically without error. Thus, for the chief tidal constituent, if the hand represented mean lunar time at starting, its error relatively in time at the end of a run of 365 days would not amount to a quarter of a minute.

The saving effected by the machine can be imagined when it is stated that the curves for a whole year can be run off in about two hours, and then only require to be read off, whilst the calculations of, say, the heights for any one port for a year, combining the 20 constituents included in the machine, would take a practised computer some four to five months' labour. The machine is used now in the predictions of over 30 Indian ports, and Mr. Roberts (who has charge of the instrument and superintends all its operations) also uses it for the predictions of the tides at Singapore and Hong Kong, and expects shortly to include in its predictions the tides of other East Indian ports, and also those of South Africa and Canada.

It may be stated that on the whole the predictions are very accurate and give very general satisfaction.

Simultaneously with the tidal observations, spirit-levelling operations were carried on, partly with a view to connect the tidal stations and ascertain whether there is any appreciable difference in the mean sea-level at the several places, and partly to connect together and reduce to a common datum the hitherto isolated system of levels which have been executed throughout the country for canals, railways, and other engineering works. During 1877–78 lines were carried from Damaun to Bombay, completing the line wanted to connect the three tidal stations on the Gulf of Cutch with the one at Bombay; from Bombay to Callian Junction of the Great Indian Peninsula Railway, and thence up the Bhore Ghât to Poona, and down to Satara; from Callian to the Thal Ghât, and thence up the Ghât to Igutpuri, Malegaon, and finally to Chikalwohol. In addition to these main lines, short branch lines were carried to connect local bench marks of importance, the aggregate length of line completed amounting to 589 miles, fixing 536 bench marks.

During 1878 the gauges continued to work well, though at Madras and Vizagapatam the occurrence of cyclones caused damage to the apparatus, and temporarily interrupted the observations. Sites for future sites, chiefly along the Arakan and Tenasserim coasts, were selected, and progress was made with the lines of spirit-levels, chiefly in the Bombay Presidency. In the following year six additional places for the erection of tidal gauges were selected, viz., False Point, Rangoon, Elephant Point, Amherst, Moulmein, and Port Blair, at which place the clerk in charge was a licensed European convict who was also the port signaller. Self-registering anemometers, and aneroid barometers, and verificatory mercurial barometers were erected at all the tidal stations, with the exception of Karachi, Bombay, and Madras; at the last two of which there were meteorological observatories already in existence.

The accuracy of the tidal registrations depends very greatly on the adjustment of the instrument both to true time and to a definitely fixed level, so that when the pencil in traversing the paper on the barrel crosses an hour-line the time should be exactly that of the hour indicated, and when it crosses a height line the height should be exactly that of the momentary height of the sea-level with reference to the bed-plate of the instrument or any fixed bench mark in its neighbourhood. The several adjustments and settings are of course made with great accuracy before the commencement of the registrations, but this would be of little use if the instruments were not maintained uniformly in exact adjustment throughout the entire period of registration. Fortunately, there was a telegraph office at nearly every place where a tidal observatory had been established, so arrangements were made to correct the clocks of the self-registering instruments to local time wherever necessary by communicating with the adjoining telegraph office. In 1880–81 the number of self-registering tidal gauges was 14, while new stations were being erected at Kidderpore, Diamond harbour, Saugor island, Bhaunagar, and Negapatam.

A complete set of all the instruments used in connexion with the tidal operations on Indian coasts was sent for exhibition to the Geographical Congress at Venice. The tide gauge was connected with the Grand Canal, and registered the tides there during the duration of the exhibition. Captain Baird was awarded a gold medal of the first class in acknowledgment of his scientific services in regard to tidal matters.

In 1880–81 the tidal stations at Madras and Bombay were connected for the first time by a line of spirit-levels carried directly across the peninsula, for the most part near the railway. At each station the mean sea-level was determined very approximately, and the result of the spirit-levelling operations over a line 730 miles was to make the mean sea-level apparently about three feet higher at Madras than at Bombay. Compared with the surface of the spheroid or other geometrical figure which most closely corresponds to the figure of the earth, there must probably be variations in the general level of the surface of the ocean at different places, and certainly where the attractions of mountains and the like are not counteracted by deficiencies of density in the strata below the elevated masses. But, as the surface of the ocean is everywhere maintained in equilibrium there can be no flow of water from one point to another. The differences of height however considerable must be insensible, because they cannot be measured by instrumental means, for the causes producing them must equally affect both the spirit-levels of the instruments and the level of the ocean. Had the spirit-levels been carried, without error, along the coast line from Bombay round, *viâ* Cape Comorin, to Madras, they must have shown identity of mean sea-level at Bombay and Madras, just as had been met with in the Red Sea and the Mediterranean, on opposite sides of the Isthmus of Suez, and in the Atlantic and the Pacific Ocean at the Isthmus of Panama. And this identity would have been obtained even if there were actually a considerable difference of height, which is very possible; for the Western Ghâts and the generally greater elevation of the western as compared with the eastern half of the peninsula are sources of attraction which if not counteracted by deficiency of density below the elevated masses must raise the mean sea-level at Bombay no less than 31 feet (according to Mr. Hennessey's calculations) above the mean sea-level at Madras. The levels, however, were taken across the continent and not along the coast line; they were carried from Bombay up the short and abrupt ascent to the crest of the Western Ghâts, and then down the long and gentle decline to the east coast, and it has been surmised that the closing discrepancy of three feet at Madras may be due to the proximate and local attractions of the hills and table-lands over which the levels were carried, or else to the accumulation of small errors, so minute as to be barely appreciable at any single station, but possessing a tendency to be repeated at

successive stations, and to attain some magnitude at the end of a long line.

During 1881–82 large discrepancies were for the first time met with between the tidal predictions and the actual facts of the tides. This arose in the case of stations situated on the banks of great rivers, as the Hugli and the Irawadi, in which the tides are influenced not only by the attractions of the sun and moon, but by the amount of water brought down by the river from its sources, which varies at different seasons of the year. The tide tables for three stations on the Hugli, two on the Irawadi, and one on the Salwen were found to be erroneous to the extent of occasionally an hour or more in the times and a foot or more in the heights of high and low water, facts which have shown the necessity for supplementing the mathematical formulæ for the harmonic analysis of purely luni-solar tides by formulæ to take cognizance of riverain influences. The subject is, however, a very abstruse one, and in the meantime Mr. Roberts has adopted a provisional method of predicting tides for riverain ports.*

One of the results of the Indian tidal observations proved about this time to furnish some light on the question of the rigidity of the earth. The subject had been mooted about 1865 by Sir William Thomson, who appealed to the universal existence of oceanic tides of considerable height as a proof that the earth as a whole possesses a high degree of rigidity, and maintained that the previously received geological hypotheses of a fluid interior were untenable. At the Southampton meeting of the British Association for the Advancement of Science Professor G. H. Darwin brought forward a numerical estimate of the rigidity of the earth, which gives evidence of "a tidal yielding" of the earth's mass, and further indicates that the effective rigidity of the whole earth is about equal to that of steel.† This theory he largely based on the results derived from the Indian tidal observations.‡

An interesting fact was also revealed from a comparison of the observations at Madras with those taken in 1821 by Colonel De Haviland, of the Madras Engineers, which is that the mean sea-level

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* *See* Tide Tables for 1883 for Diamond harbour in the River Hugli.

† Professor Darwin's later researches tended to prove that the effective rigidity is not so great as that of steel.

‡ *See also* the address of General J. T. Walker, as President of the Geographical Section of the British Association at the Aberdeen meeting in 1884.

at Madras in 1881 was about one foot lower relatively to the land than it was 60 years previously.

In connexion with the subject of tidal observations mention should be made of the earthquake which happened on the morning of the 31st December 1881 in the Bay of Bengal. It was very violent in the neighbourhood of the Andaman and Nicobar islands, more or less violent along the entire length of the west coast from Ceylon to Calcutta, and slight at various points along the east coast. The earth-waves appear to have lasted for only a few seconds, but the ocean was greatly disturbed, and the waves continued to roll against the east coast for several hours afterwards. At Rangoon, Moulmein, and Amherst there was no disturbance of river and ocean surface, but at the island of Kisseraing, below Tenasserim, Major Rogers, who was at the very moment measuring angles with one of the great theodolites, "saw the earthquake before feeling it," as the signal which he was observing (some 15 miles distant) appeared to rise and fall in the field of the telescope. On looking at the levels of the instrument he found that they were violently agitated, and he subsequently ascertained that the earthquake had been felt, at almost the same moment, at Madras and False Point, on the opposite coast. The origin or centre of impulse was therefore, in all probability, a point in the bay almost equi-distant from the three stations, but lying a little to the south.*

During 1882-83 the Paumben observatory ceased to be operative, owing partly to severe weather and partly to the observatory and equipment being more needed in Ceylon; and those at Karwar and Elephant Point were also dismantled. In all 18 groups of observations were reduced, and the so-called "constants" supplied to Mr. E. Roberts for computation of prediction tables by the tide-calculating machine.

These tide gauges afforded an unique opportunity of observing the tidal phenomena resulting from the great eruption of Krakatoa, in Java, on the 27th and 28th August. Major Baird prepared a full report on the subject, dated December 1883. His main conclusions are:—

1. The primary effect of the eruption was a marked fall in the sea-level, or, in other words, the formation of a negative super-tidal wave at each of his stations.

* Major M. W. Roger's report is printed at page 71 of the Appendix to the Indian Survey Report for 1881–82.

2. This negative wave was succeeded by a great positive wave at an interval ranging from 75 minutes at Negapatam, the station nearest Krakatoa, to 24 minutes at Aden, the most distant station.
3. Super-tidal wavelets, denoting antecedent minor eruptions, were registered at the whole of the Indian stations some hours, more or less, before the effects of the great eruption. This shows that the explosions were at first comparatively faint and feeble, being felt only at the nearest stations, but afterwards they increased in intensity, becoming sensible even at the most distant station three hours before the effects of the great eruption.
4. Great super-tidal waves of amplitudes ranging from a maximum of 22 inches at Negapatam to a maximum of 9 inches at Aden were registered at all the stations which were in a position to receive the full force of the eruptions at Krakatoa, unobstructed by the configuration of the foreshore. Other waves of less magnitude occurred at these stations at intervals of one to two hours for about 12 hours after the first great wave.
5. The secondary great waves were succeeded by wavelets gradually diminishing in size but continuing for some time.
6. Loud reports resembling the firing of distant guns were heard at Port Blair and in the Nicobar islands on the 26th and 27th August, and, being supposed to be signals from a vessel in distress, a steamer was sent out in search of the vessel. Similar reports were heard at two places on the coast of Ceylon on the 26th, first at 6 p.m. and afterwards at midnight.

These facts show that the terrible and disastrous eruption at Krakatoa, which was attended with such an appalling loss of life, was preceded for some hours by minor eruptions which were insignificant only by comparison, for they produced effects which were sensible even at Aden, a distance of upwards of 4,000 miles.*

The spirit-levelling operations carried on in connexion with the tidal operations in 1882–83 completed the last link in the long line

* General R. Strachey, R.E., C.S.I., has communicated an interesting and suggestive note to the Royal Society on the barometrical disturbances which passed over Europe between the 27th and 31st August, and investigated the speed of the barometrical waves travelling from Krakatoa round the earth.

of spirit-levels between the sea at Karachi, on the Indian ocean, and False Point, in the Bay of Bengal. This line runs from Karachi up the Indus to Mithankot and onwards *viâ* Firozpur, Agra, Allahabad, Monghyr, and Calcutta to False Point, a distance of about 2,300 miles, or as far as from London, straight across the Channel, Germany, and Russia to Astrakhan. It is probably the longest line ever run between two seas, and the error in levelling, so far as is known, does not exceed 1·7 foot, or under nine inches per thousand miles; in its absence accurate sea-level as a datum was unknown throughout the vast length it traverses.

During 1883–84 three new stations were opened at Marmagao, on the Malabar coast, and at Galle and Colombo in Ceylon. The predictions for 1883 were found to be good; they may be summarised as follows:—

Percentage of predictions within 15 minutes of actuals.

	High Water.	Low Water.
Open coast stations	72 per cent.	70 per cent.
Riverain	70 ,,	66 ,,

Percentage of predictions within 8 inches in height of actuals.

	High Water.	Low Water.
Open coast stations	92 per cent.	96 per cent.
Riverain	66 ,,	64 ,,

A connecting link was also interpolated during the following season between Sironj and a station 32 miles north of Maumad, on the Bombay and Agra road, completing a line of levels between two sea-coast stations very little inferior in length to the chain just mentioned; the closing error was only ·624 of a foot, or less than four inches per thousand miles.

In 1884–85 the observations of Beypur and Vizagapatam were closed, after a full course of work extending over five years, and their equipment was removed for the erection of two new observatories at Cochin and Coconada. At False Point the observatory was unfortunately swept away by the cyclone which committed such devastation on the coast of Orissa, on the 22nd September 1885. Captain Douglas, the port officer there, lost his life, as well as the tidal observatory clerk. Chittagong and Bhaunagar were started in

1885–86, the instruments at the latter station being provided at the cost of the Durbar. Diamond harbour, Amherst, and Moulmein were discontinued on completion of the usual period of registration, which in the case of Moulmein was extended to six years owing to certain peculiarities in the tides of that port.

An important improvement was introduced into the tide tables for 1887, by the employment of a scientific datum, which rendered it possible to fix finally the datum for each of the observatories. Previously to that the datum line of soundings adopted by the Admiralty was the "mean low water for ordinary spring tides," but as the term was not scientifically accurate with reference to tidal theory, a new datum line, called "The Indian spring low-water "mark," was definitely adopted after discussion with Professor Darwin and Captain Wharton, R.N., the Hydrographer, and a table was prepared to show the datum finally decided upon.*

In 1886 the Amherst observatory was closed and the instruments sent to Akyab, where a new station was erected, and on the night of the 29th September in the same year the tidal observatory at Dublat, near the mouth of the Hugli, was swept away with all its contents by a heavy wind and sea, and none of the instruments or records could be recovered. Fortunately the clerk was absent and no loss of life occurred.

The diagrams of the self-registering tide gauges at False Point and Dublat (Saugor island), and at Diamond harbour and Kidderpore on the Hugli, for the 11th March and 9th April 1885 show unmistakably that considerable tidal disturbances took place on those dates at the stations named. From a consideration of the facts, which are reviewed by Major Baird in a special memorandum,† it would appear that a submarine depression caused the disturbance of the 11th March, and that this was followed about a month later (9th April) by a submarine upheaval which caused a very considerable wave to pass up the Hugli. There are indications that the latter may have occurred at the Sand Heads, opposite Balasore.

The stations at Negapatam and Elephant Point were closed in 1888, and two fresh ones at Tuticorin and Prince's Dock, Bombay, were started. In 1889 the observatories at Colombo and Galle having

* The datum is defined as the sum of the semi-ranges of the principal lunar (M_2) and principal solar (S_2) semi-diurnal tides, and of the uni-solar (K_1) and the lunar diurnal (O_1) tides below mean sea level, that is to say :—

A_0 – [H of M_2 + H of S_2 + H of K_1 + H of O_1] above the zero of the gauge.

† *See* page lxxiv of Appendix to Indian Survey Report for 1886–87.

completed their registration were dismantled and the sites of three new observatories at Trincomali, Diamond Island, and Minicoy Island were selected. In addition to these it has been decided to start observatories at Jashk and Bushire.

Since the systematic resumption of tidal observations in 1877 observations have been taken at 28 observatories, of which 11 have been closed on the completion of their registration, and 17 were in operation in 1888 and the same number in 1889.

The results of the predictions for 1889 may be summarised as follows:—

Percentage of predictions within 15 minutes of actuals.

	High Water, per cent.	Low Water, per cent.
11 open coast stations	76	76
5 riverain do.	66	59

Percentage of predictions within 8 inches in height of actuals.

	High Water, per cent.	Low Water, per cent.
11 open coast stations	98	96
5 riverain do.	70	59

The constituents of the Indian tides are now computed by new formulæ investigated by Professor Darwin, in supersession of the formulæ first suggested by the Tidal Committee of the British Association.*

* A "Manual for tidal observations and their reductions by the method of harmonic analysis, with an Appendix," was compiled by Major Baird, and published by Taylor and Francis, in 1886.

IX.

GEODETIC OBSERVATIONS.

All great national surveys have for many years past contributed data for the determination of the figure of the earth. At first these consisted mainly of measurements of the distances between successive points situated on a common meridian, and of the astronomical arcs of amplitude between these points, but it is only of late years that similar measurements have been attempted in the case of points situated on a common parallel of latitude. The reason of this is that the required astronomical data are very readily obtained in the case of meridional arcs by determining the latitudes of the geodetic points, which is one of the simplest problems of practical astronomy; but on arcs of parallel, longitudes are required instead of latitudes, and the precise astronomical determination of an absolute longitude under such circumstances is well nigh impracticable. When, however, places are connected telegraphically, their differences of longitude can be determined with great precision, and this has been done both in America and Europe. In the former country the operations were utilised for geographical purposes only, but in Europe, which is covered with a net of triangulations, of which there is as yet no counterpart beyond the Atlantic, their chief interest lies in the light they throw on the figure of the earth.

At the same time these investigations have benefited the Indian Survey in a way that may be shortly explained. In order that the true latitudes, longitudes, and azimuths of the stations of a system of triangulation on the earth's surface may be computed, it is necessary that the polar and equatoreal axes of the terrestrial spheroid should be correctly known, as they are involved in the formulæ by which such computations are effected. The value of those elements that have since 1830 been used in the calculations of the Indian Survey are those known as "Everest's Constants, 1st set." Any error in these adopted elements will, of course, produce an error in the geodetical latitudes and longitudes of the stations, increasing with the distance from the originating station.

Consequently as the Indian geodetic operations have come to be extended over the whole peninsula, along the Burmese coast and across the mountains into Siam, and as far east as Bangkok, it has become more and more important to determine the amount of error in the further stations.

The data for such investigations are furnished by—

(1.) Comparison of observed latitudes with geodetic latitudes;

(2.) Comparison of observed longitudes with geodetic longitudes; and

(3.) Comparison of observed azimuths with azimuths deduced through the triangulation from the station of origin.

The astronomical observations are of great importance in various ways, among which may be mentioned that they contribute largely toward the investigation of local attraction, and also towards the accurate determination of the position of India with respect to its distance from Greenwich, and lastly they furnish data for improving existing star tables in the case of about 900 stars.

But before the application of the electric telegraph to the determining of longitudes the comparison (2) could not be made, because the longitudes determined by the old methods were not sufficiently accurate for such a purpose, a case in point being that of Madras which, though the result of many years careful observations and taken with all the refinements of a well-equipped observatory, was discovered through these electro-telegraphic operations to be erroneous by about 2½ minutes of arc, which had the effect of placing India nearly 3 miles too far from Greenwich, and of ascribing an error of 10 seconds to the chronometers of all ships arriving at Indian ports from Europe or America.* Thus the introduction of electro-telegraphic longitude operations into India was a most valuable addition to the geodetic operations of the Survey.

The Government of India have always taken a very liberal view of the more purely scientific ends of the Great Trigonometrical Survey, and almost from its commencement the operations of the Survey have furnished data for investigating the figure of the earth. Its earliest contributions to the science of geodesy were determinations of the lengths and amplitudes of meridional arcs, as described in Colonel Everest's accounts of the measurement of sections of the meridional arcs of India published in 1830 and 1847. Then came the series of Pendulum observations for the purpose of determining

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* See *infra*, p. 213.

the variations of the force of gravity at sundry stations of the Survey, situated on mountains, table lands, the interior of the continent and the coast lines, which was commenced in the year 1865 and is described in the fifth volume of the Account of the operations of the Great Trigonometrical Survey of India. And when the electric telegraph had been introduced into India, the advantage was taken to commence the measurement of differential longitudes between certain stations of the Survey, co-ordinating with the differential latitude measurements and thus to contribute to the science of geodesy determinations of a number of longitudinal arcs which were to supplement and be combined with the time-honoured Meridional Arcs.

One of the first preliminary steps for the electric determination of differential longitudes was to procure the necessary apparatus, the astronomical clocks, transit instruments, chronograph and electric appliances. On the recommendation of Colonel Walker, then Superintendent of the Great Trigonometrical Survey, the expenditure for this was sanctioned by the Secretary of State, and Colonel Strange, a retired officer of the Survey, residing in London, was entrusted with the task of designing and superintending the construction of the instruments. He had already acquired a high reputation for skill in mechanism generally, especially in regard to delicate geodetic instruments. Messrs. Frodsham, of London, were selected for the task of making the clocks, Messrs. Cooke and Sons, of York, for the transit instruments, and Messrs. Eichens and Hardy, of Paris, for the chronographs and electric apparatus. Before being sent out to India the instruments were examined at the observatory attached to the India Stores Depôt, by Colonel Strange, assisted by Captain W. M. Campbell, who subsequently took a prominent share in the observations themselves.

The instruments were received in India in 1872, and were placed in the hands of Captains Herschel and Campbell, who were then at Bangalore, which, being connected both by railway and telegraph with Madras, was a convenient starting point for the operations. The arc Madras—Bangalore was first measured, and then the sister arc Bangalore—Mangalore. The total arc was a very interesting one. In length it was not so great—its amplitude was 5° 24′ 12″, and lineal measurement 364 miles—but it was situated much nearer the Equator than any other measured arc, and, moreover, it was on that very arc of parallel that Colonel Lambton had endeavoured

in 1802-5 to determine the length of a degree of longitude, so the comparison of determinations by ancient and modern methods became peculiarly valuable.

The procedure adopted in the telegraphic operations was as follows:—Two observers were employed, one for each of the two stations to be connected. Each observer furnished with a complete set of instruments took up his position and made the most accurate determination possible of the error of his own clock, and at certain times both observers working in concert determined, by means of electric signals transmitted between the stations, the absolute difference between the clocks at a given instant. With these data the difference of longitude between the stations or arc of longitude becomes known.*

The results of the first field season's operations were unfortunately unsatisfactory: one of the transit instruments showed discordances in the 'constant for collimation' which were eventually traced to a fault in the joint of a telescope, so the observations were rejected and re-measurement was necessary.

During 1875–76 the following arcs were measured by Captains Campbell and Heaviside:—

Haidarabad (Bolarum)—Bombay.	Madras—Haidarabad (Bolarum).
Bellary—Bombay.	Madras—Bellary.
Haidarabad (Bolarum)—Bellary.	Bangalore—Bellary.

During the next year (1876–77) the following arcs were measured by the same officers:—

Vizagapatam—Madras.
Vizagapatam—Bellary.
Mangalore—Bombay.

In almost all the cases the trigonometrical values were found to be greater than the telegraphic. This is due partly to the circumstance that the constants for the figure of the earth, used in the computations of the geodetic latitudes and longitudes of the Indian Survey, are not quite exact, and partly to local deflections of the plumb-line at the stations of observations, which indicate (in accordance, it may be observed, with the results of Captain Basevi's pendulum observations) a probable greater density in the strata of the earth's crust under the beds of oceans than under continents.

* Volume IX. of the operations of the Great Trigonometrical Survey of India, page xiv.

On the completion of the operations between Bombay and Mangalore, Captains Campbell and Heaviside proceeded to determine the differences of longitude between Bombay, Aden, and Suez, in order to complete the connexion between England and India, of which the section from Greenwich to Suez had been executed on the occasion of the Transit of Venus in 1874, under instructions from Sir George Airy, the Astronomer Royal. The Eastern Telegraph Company kindly granted the gratuitous use of their cables, not only during the actual work of signalling, but also during the preliminary tentative measures. In these operations Captain Campbell devised a sort of automatic method of comparing the clocks through the cables, so that no personal errors of observing or repeating signals could enter. The results were to establish the following values*:—

		h.	m.	s.	
Station at Aden - -	=	2	59	55·83	East of Greenwich.
Observatory at Bombay -	=	4	51	15·81	
Observatory at Madras -	=	5	20	59·34	

The longitudes of all places in India are usually referred to Greenwich through the Madras observatory, the position of which has been determined at various times by astronomical observations. The latest determination had been 5h. 20m. 57·3s., or 80° 14′ 19·5″ east of Greenwich, and this had been for many years the accepted value, being that given in the Nautical Almanac. The effect of these electro-telegraphic observations was to show that this value was about 2 seconds of time or 30·57 seconds of arc in deficit of what is probably the true value, *i.e.*, 80° 14′ 50·03″ E.*

In 1877 both officers took furlough, and on their return the Afghan war intervened, but in 1880–81 operations were resumed and the following geodetic arcs were measured :—

Bombay—Disa.	Jabalpur—Haidarabad (Bolarum).
Disa—Karachi.	Jabalpur—Agra.
Bombay—Karachi.	Jabalpur—Disa.
Jabalpur—Bombay.	Agra—Disa.

During the following season seven arcs were measured between Faizabad, Agra, Jabalpur, Hazaribagh, Calcutta, and Jalpaiguri,

* See p. xviii. of Vol. IX. of "Account of Operations of the Great Trigonometrical "Survey of India." It has been recently suggested that Indian longitudes should be referred direct to Greenwich, so as to avoid the discrepancies arising from the fact of the true longitude of Madras Observatory being above 2½ minutes west of its accepted position on Indian maps.

but owing to a defect in No. 2 transit telescope similar to that found in 1872–73, three of these arcs were remeasured in the following year as well as five new arcs, and in 1883–84 the operations moved eastwards of Calcutta as far as Moulmein, thus completing the last link between Karachi and Moulmein.

In 1884–85 Major Heaviside resumed the observations for astronomical latitudes with the zenith sector, which had been in abeyance since 1871–72. He observed at stations about half a degree apart down the Amua meridional series, commencing about latitude 28° 30′ N. and carrying them south over five degrees of the arc, which was eventually to be extended to Madras in latitude 13° 4′. The results are given in the appendix to the Survey Report for 1885–86, p. lviii.

No fewer than nine arcs were measured for longitude by electro-telegraph in 1885–86, but, unfortunately, when the results came to be reduced and compared in the recess season, it was found there was a mysterious source of appreciable error, for out of five verificatory circuits† three exhibited errors between a quarter and a third of a second of time. These irregularities were investigated with the greatest care during the following season by Colonel Haig, Lieutenant S. G. Burrard, R.E., and Mr. Eccles, and every possible interchange of observers, telescopes, electrical apparatus, and stations was secured in a series of observations on a short experimental arc at Dehra Dun. The observations tended to show that the longitude operations had been harassed by three sources of error, viz., (1) electrical, (2) local, and (3) instrumental. But it must be borne in mind that these so-called errors are intrinsically so minute as to be of no consideration whatever, except from a purely scientific point of view.‡

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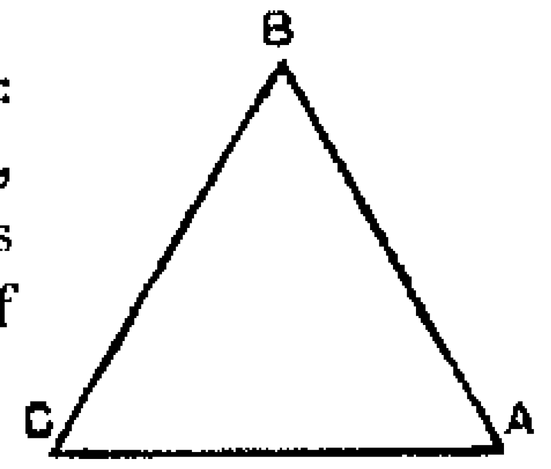
* The whole of the details and results of the observations from 1875–76 to 1883–84 will be found in Vols. IX. and X. of the "Account of the Great Trigonometrical "Survey," &c. mentioned in the previous note.

† Any three arcs forming a triangle offer a verificatory circuit: thus the sum of the arcs A B and B C is equal to the arc A C, therefore, if the sum of the *measured* arcs A B and B C differs from the *measured* arc A C the difference is due to error of measurement in one or more arcs.



‡ They have since been traced to the determinations of the errors of collimation of the telescopes, which indicate either slight weakness in the telescope tubes, or irregularities in the object glasses, which were not always exactly centered between the collimators in determining the collimation.

During the early part of this season (1886–87) Lieutenant Burrard continued the latitude observations with the zenith section near the meridian of 80°, observing at five stations and so extending the arc to about Latitude 20° N. The longitude operations were resumed in Southern India, and the following arcs were measured :—

1. Madras—Bangalore.
2. Bangalore—Nagarkoil (near Cape Comorin).
3. Madras—Nagarkoil.
4. Nagarkoil—Mangalore.
5. Madras—Mangalore.
6. Bellary—Mangalore.
7. Mangalore—Bombay.

Nos. 1 and 5 were revisions of the work executed in 1872–73 and rejected (as mentioned above) owing to a fault in the telescopes, and No. 7 the arc which was left incomplete in 1876–77.

Three of the old arcs in Southern India were revised in addition to four new ones being measured. The season's measurements tended to confirm a curious geodetic fact that the plumb-line round the coasts of India deviates in the direction of the sea. They were also satisfactory in showing a diminution in the circuit errors which was probably as small as can be expected, while the value obtained for arc No. 7 differed only by 0·023 of a second from the value of the same arc as measured in 1876–77.

Operations were resumed in 1889–90 in the Punjab, Baluchistan, and Central India. Seven arcs were measured, including the revision of one formerly measured in Baluchistan, and the measurement of a cross-arc, Agra-Karachi.

X.

SUPPLY OF SCIENTIFIC INSTRUMENTS.

The supply of accurate instruments constructed on the most recently approved principles by skilled mechanicians has largely conduced to the precision of modern surveys. In 1862 the Secretary of State perceiving that the supply and examination of instruments for use in India were requirements likely to increase rather than the reverse, appointed Lieutenant-Colonel A. Strange, F.R.S., to supervise and test all scientific instruments destined for India. Colonel Strange was an officer possessing high qualifications for the post; he had had considerable practical experience in trigonometrical surveying, while his mechanical genius and knowledge of mathematical, geodetical, and astronomical instruments were not surpassed by any man in England. A special observatory* and office were erected at the India Store Depôt in Belvedere Road, Lambeth, and since then the examination of instruments has steadily proceeded, the number of kinds of instruments annually dealt with being now close on 200, or about twice as many as in 1871. The effect has been to bring about a vast improvement in the quality of the appliances. In the early part of 1876 Colonel Strange died, and in June of the same year the Secretary of State appointed Mr. Thomas Cushing, F.R.A.S., to succeed him as Inspector of Scientific Instruments. Mr. Cushing had also had much practical training and experience in his earlier career as a scientific mechanician, besides having been for nine years assistant to Colonel Strange. During the last three years the number of instruments examined by him has averaged about 10,000 per annum (valued at 30,000*l.*) as against 7,000 in 1871.† Among them may be specially mentioned a six-inch equatoreal telescope, a large reflecting telescope and an observatory dome for the Poona College of Science, as well as costly physical apparatus of a varied kind for the use of colleges in India, amounting in value to 1,714*l.* For the Survey Department only instruments of the highest order are sent out, long experience having shown this is most economical in the end.

* A description of the observatory will be found at page 201 of the "Memoir on the Indian Surveys" (2nd ed.).

† Appendix I. shows the character, number, and value of the scientific instruments examined at the Lambeth Observatory during the three years ended 1890.

In the year 1879 Mr. Cushing brought out a new form of levelling instrument which he called a "reversible" level. The objects were to facilitate the adjustments, make the instrument more compact and rigid, and render the surveyor independent of the aid of an instrument-maker should anything go wrong when in the field. Several hundreds are in use at the present time in India.

The tide-predictor, constructed for the Indian Government by Messrs. Légé and Co., is located in the observatory at Lambeth, and with its aid tide-tables for upwards of 20 ports are annually printed and forwarded to India towards the end of the year preceding the one for which they are prepared. The tides for several ports are also predicted for the Colonial Office. This work is very ably done by Mr. E. Roberts of the Nautical Almanac Office.*

During the year 1889 three new standard yard measures were constructed in England by Messrs. Troughton and Simms as primary standards of length for the Governments of Bengal, Bombay, and Madras, and were verified by the Standards Department of the Board of Trade. It may be interesting to know that these important standards do not absolutely agree in length, but they are probably as near as human skill can make them. The standard temperature of India having been fixed at 85° Fahrenheit, the certificates of verification, which were forwarded to the respective Governments with the standards, show their respective lengths at that temperature, which are as follows :—

Bombay	-	36·00023406 inches.
Calcutta	-	36·00039041 ,,
Madras	-	36·00007206 ,,

And the co-efficient of expansion in each case is the 0·0003744 of an inch.

The mints of Calcutta and Bombay were each supplied in 1889 with new sets of standard tola weights, all of which were verified by the Standards Department of the Board of Trade, and the tables of errors were supplied to the respective mints with the weights in question.

The Calcutta mint also received a large balance, constructed by Napier, for weighing silver. It was a splendid piece of mechanism, made to carry upwards of 380 lbs. avoirdupois in each pan and to

* For a description of the tide predictor, *see* p. 199.

turn with two grains, which is a quantity less than the one-millionth of the weight in each pan. It is needless to say that such accuracy requires the highest mechanical skill in the construction, and such a balance, which must necessarily be costly, deserves the greatest possible care in use, notwithstanding that it is so constructed that the pans can be loaded before the knife-edge is brought into contact with the plane on which it acts in weighing.

Besides the above department in London there is a similar department in Calcutta called the Mathematical Instrument Office, which receives and takes charge when necessary of all the instruments constructed in Europe for the Survey Department, manufactures those which can be made most economically in India, repairs those which are damaged, and keeps up a stock of serviceable instruments for issue to the Survey and other public departments in the Bengal Presidency. It has always been under the superintendence either of the Deputy Surveyor-General or one of the senior officers stationed in Calcutta, but it was not until 1877 that a report on this branch was issued. Since then the work done has been regularly noticed in the Surveyor-General's Report. In April 1878 the number of instruments in store at Calcutta was nearly 37,000, about a third of which belonged to the Public Works Department and a nearly equal number to the Survey, the remaining third being distributed among other departments. The principal description of instruments issued are :—

To the Survey Department.—Aneroid barometers, binoculars, chains, magnetic compasses, drawing instruments, heliotropes, reading lenses, plane-tables, planimeters, protractors, flat rules, scales of various sorts, optical squares, telescopes, and theodolites.

To the Marine Department.—Barometers, binoculars, Massey's patent logs, carpenters' rules, drawing instruments, sympiesometers, telescopes, and thermometers (but all in very small numbers).

To the Military Department.—Pocket aneroid barometers, sketching cases, prismatic compasses, drawing instruments, reflecting levels, protractors, scales of various sorts, pocket sextants, and tapes.

To the Public Works Department. — Drawing boards, chains, compasses, curves, drawing instruments, levels, protractors, carpenters', rules, flat rules, scales of various sorts, levelling staves, tapes, and theodolites.

To Miscellaneous Departments, viz., Meteorological Department, Telegraph Department, Educational Department, and others.—

Aneroid barometers, chains, drawing instruments, prismatic compasses, surveying compasses, protractors, flat rules, scales of various sorts, pocket sextants, tapes, thermometers, and wind-vanes.

The rates at which instruments were locally purchased in Calcutta in 1879 were, on the average, about 34½ per cent. higher than those at which the instruments received from England had been issued to the public service, and which were themselves 20 per cent. above their English prices, in order to cover freight and other charges. Moreover, the articles purchased in the local market were seldom equal in quality to those received from England.

The departmental manufactures, valued at about 10,000 Rs. in 1878, and consisting chiefly of chains, hand map-printing machines, drawing boards, plane-tables, pluviometers, stands for compasses, plane-table telescopes, &c., were issued, as far as could be ascertained, at about two-thirds of the value at which similar articles could be issued if procured from England. In repairing too a very considerable amount of work is done, *i.e.*, about twice as much as in manufacturing. Among the repairs was that of the great 24-inch theodolite which was used with great success by Colonel Branfill in Southern India, and among the new instruments manufactured was an idiometer, designed by Lieutenant-Colonel W. M. Campbell, R.E., the object of which was to afford means of measuring the absolute personal equations in observations of star transits recorded on a chronograph. The general arrangement is that of a moveable frame carrying vertical wires in imitation of the wires of a telescope, which passes in front of a fixed imitation star; a small observing telescope is attached to the wire frame so as to follow its movements, and thus the appearance of fixed wires and a moveable star is obtained. As each wire passes the star two signals are recorded on the chronograph, one by the observer and the other automatically by the instrument.

In 1884 a fine circular dividing machine by Troughton and Simms, which had been obtained from England some years previously for the Madras Public Works Department workshops, and had lain there unused, was transferred to the Mathematical Instrument Office, where it was set up. It proved to be of great use, enabling the limbs and verniers of many damaged theodolites, which would otherwise have had to be rejected or sent to England for repair, to be re-divided. In the following year a machine was imported from England for the purpose of testing all aneroid

barometers by a standard, in lieu of sending them to the Meteorological Department.

In 1888 the Mathematical Instrument Department was located in its present handsome building,* which had been commenced the year previously. The transfer from the old house (one of the oldest in Calcutta) was not too soon, for some of the beams showed unmistakeable signs of collapse, and the steam engine had to be stopped for fear of disaster. It was found that the large majority of the beams had been gutted by white ants, and it was fortunate that the house did not fall to ruins before it was vacated. The new building has fairly ample accommodation for workmen, stores, &c., there is an observatory on the roof in which a transit instrument has been set up for rating chronometers, and a new steam engine and shafting have been erected.

During the last 12 years there has been a great increase in the work of the Department, necessitated by fresh annexations of territory in Burma and Baluchistan, the development of railways, roads and public works, and a general increase in the scientific requirements of the administration. The number of instruments issued in the year 1887–88 was 57,293, valued at Rs. 2,25,599, while out of the total stock 7,387, valued at Rs. 1,16,246, were procured from England, 31,846, valued at Rs. 35,252, were purchased in the local market, and 17,960, valued at Rs. 33,320, were manufactured in the Mathematical Instrument workshop. The last number shows a large increase, nearly 100 per cent. over the figures of the previous year, and the value has risen by nearly Rs. 10,000.

* There is a capital photograph of the new building at page 92 of the Surveyor-General's Report for 1887–88.

XI.

HEADQUARTERS OF SURVEY DEPARTMENT.

The Headquarters Offices of the Department of the Surveyor-General comprise six different offices, five in Calcutta, and one in Dehra Dun, whence the operations are directed, and where the results of the field surveys are worked up into final shape for general administrative use. These offices consist of—

(1.) The Surveyor-General's Office (including also the drawing, engraving, and map issue branches).
(2.) The Lithographic Office.
(3.) The Photographic Office.
(4.) The Mathematical Instrument Office.
(5.) The Revenue Survey Office.
(All at Calcutta.)
(6.) The Trigonometrical Survey Office at Dehra Dun.

In 1877 the Calcutta branches were still in different buildings some distance apart one from another, and a good deal of inconvenience was felt in consequence. This anomaly and inconvenience had long been felt and recognised by Government sanctioning designs for new offices; but it was not till 1882 that any part of the new building was sufficiently advanced to be occupied. In that year the new building designed to accommodate the Surveyor-General's and Revenue Survey Offices was ready, and within a month after the close of the year the houses in Park Street and Middleton Street, in which the offices had previously been located, were vacated, and the entire stock of maps and records—the collection of nearly a century—of copper plates, and plant of all descriptions, was transferred to their new quarters. The new building proved to be well designed and constructed. It is commodious and airy; it gives sufficient space for all the members of the office, and excellent accommodation and lighting for the engravers and draftsmen, who had long had to work in crowded and inadequately lighted rooms. In 1882–83 it was decided to amalgamate the correspondence and accounts offices of the Surveyor-General's Office and the Revenue

Survey Office under one Registrar, and form three sub-offices, the Surveyor-General's Office, the Revenue Branch, and the Topographical Branch Offices, each under the immediate supervision of its own head clerk. The work of the Drawing Office divides itself so distinctly into two classes, the geographical drawing and that connected with large scale revenue maps, that it was found advisable to keep up two sections of the office for the two classes of work, though for administrative work the clerical staff were all amalgamated into one list under one Assistant Surveyor-General. The new building for the accommodation of the photographic and lithographic offices was not completed till 1889 and was finally taken into occupation at the end of September in that year. These offices which had been for many years scattered between three houses, of which one was at some distance from the others, were thus concentrated under one roof, and this concentration, together with the introduction of steam printing machines, enables them to work with far greater economy and efficiency than was possible previously.

A large and important part of the work of the Surveyor-General's Office consists in compiling urgent maps and preparing pressing data for other departments. With a view to prevent interruption of work and to ensure a more perfect scrutiny of the geographical compilations and publications, a special examining branch was organised in 1877–78, and located in a separate part of the Surveyor-General's Office.

The engraving branch have to cope with two classes of work, viz.:—(1) the sheets of the Indian Atlas on the quarter-inch scale, and (2) provincial and other compilations and maps of India on smaller scales than the atlas. The increasing amount of labour thrown on the branch made it necessary after a time for the data engraved on the copper to be confined to the results of actual survey, all questionable details being left blank or drawn on the plate by hair lines. The engraving branch contains a large number of natives who have been trained by Mr. Coard, the late superintendent, and his assistants to do the more mechanical part of the work very satisfactorily. But strange to say, the natives do not appear to possess the artistic skill requisite for hill etching, though at first sight it was imagined that this was precisely the class of work at which they might be expected to excel, and so the hill engraving has had to be assigned almost entirely to Europeans.

A considerable amount of labour was thrown on the Department by the preparation of a list of the latitudes and longitudes of all the places in Dr. Hunter's Imperial Gazetteer of India. This was successfully completed in 1879.

In July 1878 Captain Waterhouse went to Europe on privilege leave and visited the Paris Exhibition and other places to investigate the most recent improvements in photography as applied to map reproduction. He also studied the process of *heliogravure** practised at the Military Geographical Institute, and secured for the Department the right of using Mr. Willis's *platinotype* process, a good permanent substitute for silver printing.

During the year 1879–80 the demand for maps of Afghanistan was very great and urgent, and it taxed the resources of the Department to the utmost to utilise speedily the new surveys which kept coming in from the seat of war from time to time. Five editions of the large map issued under the successive titles of the two routes to Kabul and the seat of war in Northern Afghanistan were compiled and published on the quarter-inch scale. Two editions of the map of Quetta to Kalat-i-Ghilzai and Girishk and a first edition of the map of Sibi to Quetta and Tal-Chotiali to the Pishin valley were published on the same scale, and a new map of Southern Afghanistan and Baluchistan was also taken in hand and completed during the ensuing year.

The process of steel-facing the copper plates of the Indian Atlas to prevent wear has proved very successful. For some years a large number of the plates had been thus treated and none of them showed the least sign of wear or of suffering from rust, while the system possessed another advantage in the fact that it was no longer necessary to make transfers from the copper to stone, and that the clearer and sharper impressions could be taken directly from the plate without fear of injury to its surface.

A very useful engraved general map of India on the scale of 32 miles to the inch was completed in 1881, to take the place of the old skeleton map which had done duty for many years. Progress was also made with two smaller maps on the scales of 64 and 96 miles to the inch respectively. During the same year the map of Southern Afghanistan in four sheets was also issued. There was a considerable diminution in the out-turn of geographical and military maps owing to the withdrawal of the British troops from

* Described in the Appendix to the Survey Report for 1881–82.

Afghanistan; but, on the other hand, there was a great increase in the number of cadastral maps printed, the voluminous character of which has always proved a very laborious undertaking.

The despatch of the Indian troops to Egypt in 1881–82 necessitated the drawing and publication of a map of Lower Egypt, as well as maps of the Suez Canal, Cairo, and Alexandria. All these came into great demand on the outbreak of hostilities. Happily the collection in the Survey Department contained some excellent French maps of Egypt, and from these single specimens large numbers of copies were rapidly obtained by photo-zincography, issued to the troops, and also sold to the public.

In September of the same year (1881) the Venice Geographical Congress and Exhibition took place. Colonel C. T. Haig, R.E., was delegated thither by the Government of India as their representative, and Sir Henry Thuillier and Captain Baird were subsequently deputed in the same capacity from England by the Secretary of State. Sir H. Thuillier and Colonel Haig were also appointed British Commissioners by Lord Granville. Collections of maps, charts, &c., were despatched by the Indian Government, Ordnance Survey, and Admiralty, and the Indian delegates obligingly took charge of the arrangement and organisation of the English maps, &c., in addition to their own exhibits, which included a large and representative selection of Indian maps, as well as the great theodolite and other survey and tidal instruments. Two letters of distinction (the highest award) were given to the Survey of India in Classes I. and VIII., as well as two medals for native explorers (already mentioned at page 88, *note*), a diploma of honour to the Marine Survey of India, a medal to Captain Baird for his tidal work in Class II., a medal in Class I. to Colonel Haig for his topographical maps of Gujrat, and a medal in Class VI. to Dr. Hunter for his Gazetteer of India.*

A map, based on triangulation, of the Nizam's dominions was commenced in the following year, the old topographical sheets being re-drawn in the regular standard forms on the one and half inch scales and in a style fit for reproduction by photo-zincography. The materials were very old, being derived from surveys in the early part of the century. Unfortunately though old they are the only materials available, no modern survey having been as yet made of this enormous expanse of country in Southern India, though detached portions here and there have fallen into the field of adjoining parties. During the same year (1882–83) an irrigation

* *See* Reports in Appendix to Indian Survey Report for 1880–81.

map of the North-West Provinces on the scale of eight miles to the inch and a rainfall chart of India with eight gradations of colour were also prepared. The heliogravure process also made steady progress, and seven plates were turned out, four being for the Geological Survey, one outline map of Simla and Jutog, and two plates of a view of the great Kan-chan-janga mountain.

In 1883–84 some of the special maps drawn for the Calcutta International Exhibition were prepared for publication, viz., those exhibiting trade routes, distribution of religions, missionary stations, density of population, distribution of languages and river basins; the rainfall, railway, and telegraph maps having been already published.

An elaborate plaster of Paris model map, based on the 32-mile map of India, showing all the hills as well as the scale would allow, was completed for the Colonial and Indian Exhibition of 1886 by Major Charles Strahan, R.E. The vertical scale was 12 times the horizontal, hence the highest peaks of the Himalayas were nearly two inches high.* In the same year (1884) a very successful reproduction of a quarter atlas sheet by the electrotyping process was made by Colonel Waterhouse, the method of scraping away the faulty parts from the matrix being suitable where large corrections on a plate are required and the ordinary mode of cutting out and hammering up from behind might seriously damage the plate. Considerable progress was also made in the various processes of heliogravure by the electrotyping and etching methods, and 79 plates (principally of photographs of Indian art-works taken in the Calcutta Exhibition) were produced. Considerable attention was also given to the reproduction of maps, and some very successful experiments were made in reproducing brush-shaded maps by the photo-etching process. With suitable original drawings the heliogravure processes can be made to render immense service in the cheap and speedy production of engraved maps. The process of electrotyping was also applied to the duplication of the engraved sheets of the Atlas of India so as to adapt them for temporary issue, pending engraving of the final results, and good progress was also made with the photo-collotype process which was used for plates of coins for the Asiatic Society, for botanical plates, and the like. The principal map completed in the Lithographic Office during the year was a contour map of India in six sheets on the scale of 1 inch to 32 miles.

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* This relief map has since been presented to the Imperial Institute.

During 1885–86 a great deal of drawing and compiling work was done for the Indian and Colonial Exhibition in London. A map was prepared showing the import and export trade of India with other countries, and a series of maps showing at a glance the percentage of various crops grown in different districts of India, with other maps showing density of population, religions, emigration, external trade, land settlement and revenue, and geology of India was also completed.

In the Lithographic Office a series of maps were prepared for Sir E. Buck's Statistical Atlas of India, and the map of the Nizam's dominions in two sheets on the 16-mile scale referred to above was printed off.

The following year (1886–87) was marked by a great demand for maps of Afghanistan and Baluchistan, consequent on the events on the Afghan frontier. Compilations from rough military reconnaissances in Burma had also to be undertaken. The Engraving Office lost the services of Mr. C. W. Coard, the superintendent, who had been selected, together with a small staff of engravers, in 1868 by Colonel Thuillier, then Surveyor-General, to take up the engraving of the Indian Atlas sheets. Mr. Coard had done excellent work during his tenure of office, and had left the engraving branch in a high state of efficiency. He was succeeded by Mr. G. G. Palmer.

The work done in the heliogravure and collotype sections was more satisfactory in quantity and quality than previously, both processes having quite emerged from the experimental stage into practical methods. A commencement was made in reproducing archæological drawings for the use of art schools and also for the illustration of the Journal of Indian Art.

During 1887–88 greater strain was put on the geographical drawing and compiling branch in consequence of the necessity of preparing general maps of Burma and sheets of the N.W. frontier, and it was with difficulty that sufficient material could be got ready to keep the engravers employed. To remedy this it was arranged that all the N.W. frontier mapping, except Baluchistan, should be undertaken at the Trigonometrical Branch Office at Dehra Dun, leaving the Burma maps to be dealt with in the Calcutta Office.

One of the principal features of the period under review has been the introduction of the heliogravure processes for the direct reproduction of delicate drawings in line or of half-tone subjects of all

kinds, and of electrotyping for the duplication and correction of hand-engraved maps.

The first experiments in heliogravure were made, with fair success, about 1877 with a photo-electrotype process based on Geymet's, which was originally brought out by Mr. J. W. Swan, the inventor of the carbon process. In the following year Captain Waterhouse, while in Europe on privilege leave, visited the Military Geographical Institute at Vienna, at that time the only large geographical office working the process, and obtained a good deal of valuable information regarding it; but little progress was made till 1882, when he introduced a new process for producing "grain" on the plates of half-tone subjects which he had worked out, with the aid of the Autotype Company, while on furlough in 1880-81. In this process the wet-gelatine relief is dusted over with sand or some similar granular material, previously waterproofed by treatment with a greasy substance like wax, so that it might easily be removed from the gelatine relief when dry. The effect of the sand was to roughen the gelatine surface proportionately to the depth of gelatine and so produce a graduated grain stronger in the shadows than in the lights. The gelatine surface was then blackleaded and electrotyped. In this way an engraved mezzotint plate was produced from which very perfect half-tone prints could be printed. This process proved very valuable for the production of some 3,000 copies of the "Award Certificate" of the Calcutta Exhibition in 1883-84, and several plates of illustrations of Indian art-ware in the Exhibition as well as of brush shaded maps and drawings were reproduced by it, but owing to climatic causes it was always rather a difficult process to work, and the plates required a good deal of touching up.

In 1884, with the assistance of a skilful carbon printer, Mr. A. W. Turner, experiments were made with the photo-etching process, which was on the same principle as the photoglyphic process originally invented by Fox Talbot, and which had recently been re-introduced with modifications by Herr Kliç of Vienna.

The process was worked out successfully on the bare information obtainable from the photographic journals, but further improvements, learnt at the Military Geographical Institute in Vienna, during Colonel Waterhouse's furlough in 1886, were introduced in 1887, and since that time the process has been working on a perfectly practical footing and is found very valuable for all kinds of delicate work in line or half-tone. It has the great advantage

over photo-collotype, which was also worked with some success at Calcutta, that the copper plates can be worked on and lettered and, if protected by a coating of steel, are capable of yielding an unlimited number of equally good impressions, whereas the tender gelatine film of the photo-collotype plate will stand no touching up or correction, is difficult to print under varying conditions of temperature and humidity, and at best will only yield a comparatively small number of good impressions, while all lettering has usually to be added by a separate printing. Consequently, photo-collotype is being discarded in favour of photo-etching.

The principal applications of the photo-etching process have been for the reproduction of some very delicate drawings of insects in pencil and Indian ink, for the illustration of the "Indian Museum Notes," also for botanical and histological plates from the original drawings or photographs, illustrating the "Memoirs by the Medical Officers of the Army in India." A large proportion of the plates, illustrating Dr. Führer's Report on the Sharqi remains at Jaunpur, both from photographs and line drawings, were done by this process, and no other would have answered so well. It is also steadily utilised for the reproduction of a series of technical drawings of architectural ornaments, &c., taken from the drawings of the Archæological Surveys and issued for the use of art schools and workmen of various kinds in all the provinces of India.

Attempts have been made from time to time to apply the process to the reproduction of brush-shaded maps and by its means enable a preliminary issue of the sheets of the Atlas of India to be made pending the completion of the hill-etching by hand, which is always a tedious operation. There are, however, great difficulties to be overcome in reproducing lines and brushwork together, which have practically prevented its utilisation in this way, although it is always kept in view. The process might be more largely applied to the reproduction of maps in line, but the difficulty has been to obtain a staff of highly trained draughtsmen capable of turning out the original drawings in a sufficiently good style for direct engraving. The necessity for constant corrections on the maps also militates very greatly against the preparation of highly finished drawings capable of competing against hand engravings. The process has, however, been successfully applied to the reproduction of the maps of the Andaman Islands on the $\frac{1}{4}$-inch scale, by reduction from the original standard sheets on double the scale, and, no

doubt, as time goes on, it will be much more largely employed for map work.

The process of electrotyping was first introduced in connexion with the photo-electrotype process of heliogravure about 1882, and has proved very valuable in connexion with that process, and also as an economical means of duplicating engraved plates of standard maps in various stages of their progress, in order to obtain skeleton maps with varying amounts of detail, suitable for the illustration of reports and other administrative purposes. It has also been found very useful in carrying out extensive corrections on the engraved plates; a matrix being made from the original plate, the parts in relief corresponding to the parts to be corrected are scraped away and a duplicate plate is electrotyped on which the faulty parts present a blank flat space upon which the new details required can be engraved. The process is scarcely ever used, as it is at the Ordnance Survey Office, Southampton, for producing printing plates, as the process of steel-facing which enables the original engraved plates to be printed from without injury has been found to be cheaper and more suitable for the requirements of the Indian Office.

The electrotyping method in use is practically the same as was practised for many years at the Military Geographical Institute in Vienna, and consists of a horizontal single-cell apparatus in which an electrical couple is formed by the copper plate to be deposited on, which rests on a suitable support in a bath of sulphate of copper, and an iron plate immersed in dilute sulphuric acid, contained in an upper tray with a leathern bottom which forms a porous diaphragm. These batteries are found to work with regularity and practical economy, being very simple in working and easily looked after by natives. The electrotyping work is done in the Photographic Office.

Probably the most important cartographical work of the Calcutta Office is the Indian Atlas. This great work is on the scale of four miles to the inch; it is the standard map of India, and embodies the results of the detailed surveys. It is designed to cover 181 full sheets, 40 inches by 27, on the globular projection and scale originally proposed by Mr. Aaron Arrowsmith, and the region embraced extends from Karachi to Singapore and from Gilgit to Cape Comorin. It also includes Ceylon. The original sheets, for which the Madras Topographical Surveys furnished the materials,

were produced by Mr. John Walker in 1827. In 1864, with a view to expedite the work, a proposal was made by the Surveyor-General that the Atlas should be brought out in quarter sheets, and this was agreed to by Mr. Walker. The convenience of this mode of publication has been universally recognised since and the practice uniformly adhered to, the old full sheets being now discontinued. In 1868 the engraving of the Indian Atlas was formally transferred to Calcutta, and a small but efficient staff of experienced engravers under Mr. C. Coard, was engaged by Colonel (now Sir Henry) Thuillier, the Surveyor-General. These were reinforced in 1872 by fresh hands selected by Colonel J. T. Walker, who at the same time made arrangements for the completion of the engraving of all the plates remaining in England. Since 1876 the engraving has been carried on entirely in Calcutta at the headquarters of the Surveyor-General, within easy reach of the compilers and surveyors, to whom reference is made in cases of doubt or difficulty.

It must not be supposed, however, that the Indian Atlas, though commenced as far back as 1825, is near completion.* This arises

* The following table, taken from Captain George M. Wheeler's (U.S. Army) admirable report upon the Third International Geographical Congress and Exhibition at Venice in 1881, will serve to show how far the European countries had advanced in 1885 towards the completion of their general topographic maps:—

Country.	Area in Square Miles.	Scales.	Number of Sheets when complete.	Number completed.	How reproduced.†
Great Britain - -	123,185	1: 63,360	696	412	C.
Germany - -	208,368	1:100,000	674	417	C.
Austro-Hungary -	241,553	1: 75,000	720	578	Hlg.
France - -	205,976	1: 50,000	1,092	20‡	Z.
„ Algeria -	166,023	1: 50,000	327	23	Z.
Switzerland - -	15,978	1:100,000	25	25	C.
Holland - -	13,740	1: 50,000	62	62	S.
Spain - -	193,286	1: 50,000	1,080	29	S.
Italy - - -	111,405	1:100,000	277	109	Ph. z.
Sweden - -	173,967	1:100,000	232	64	C.
Russia - -	2,129,201	1:126,000	972§	505	C.
Belgium - -	11,375	1: 40,000	72	72	C.
Denmark (Jutland) -	14,788	1: 40,000	131	69	C.
„ (Islands) -		1: 80,000	29	29 (in quarter sheets).	C.
Norway - -	125,646	1:100,000	54	43	C. and S.
Portugal - -	34,418	1:100,000	37	22	S.

† C. Copper engraving; S. Stone engraving; Z. Zincography; Ph. z. and Ph. l. Photo-zincography and Photo-lithography; Hlg. Heliogravure.

‡ This map is intended to supersede the État Major map on the scale of 1:80,000 in 273 sheets, which was commenced n 1819 and finished in 1881.

§ Approximate.

partly from the magnitude of the scheme which embraces the whole of Burma and the Malay peninsulas and partly from the necessity of replacing the sheets compiled from old surveys by more accurate work as soon as practicable. The last index map shows that nearly the whole of India west of Burma has been completed and published, the exceptions being Nepal and parts of Gujrat and Rajputana. But the greater part of the Punjab, the Lower Provinces, Madras, Haidarabad, the Berars, the western part of the Bombay Presidency, and Sind are derived from old materials and will have to be re-engraved. In fact, the Indian Atlas sheets that are based on trustworthy surveys (which consist for the main part of a broad belt running north-west and south-east from the Punjab to Jeypur and the Mahanadi, with the addition of Assam, Kathiawar, and the greater part of Cutch) are less numerous than those which do not come up to the modern standard of accuracy. It will thus be seen that there is an enormous area still awaiting the energies of the Department both in mapping and field work before even a satisfactory first survey of India is available.

The number of sheets according to the original scheme of the Indian Atlas was 177, which included the whole of Burma (at that time independent of the British Crown) right up to, and even beyond, the Salwen river. Events have proved that this precaution was a wise one, and that the wide margin allowed in this direction was not too liberal. But in the extreme north India has outgrown the limits of the Atlas, and three new sheets, 14A, 27A, and 44A (to include Chitral, Gilgit, and Baltistan), have been laid down, while fresh sheets will probably have to be added for Baluchistan, which is now, to all intents and purposes, incorporated into our Empire. A special arrangement, too, has been sanctioned, by which the Indian Atlas is being supplemented by a complete and homogeneous belt of maps illustrating all the transfrontier regions from Baluchistan round by way of Tibet to Burma, on the same scale as the adjacent Atlas sheets, a most convenient plan in consequence of the unavoidable expansion of the Indian Empire.

The following are the other principal maps in general demand:—

(1.) India. Scale, 32 miles = 1 inch, in six sheets.

(2.) India, 64 miles = 1 inch, engraved, in four sheets.

(3 and 4.) Railway maps of India on 48 and 64 mile scales, photo-zincographed with hills in grey.

(5.) Turkestan. Scale, 32 inches = 1 mile. 6th edition. Photo-zincographed, in four sheets.

(6.) Afghanistan. Scale, 24 miles = 1 inch. Photo-zincographed, two colours, in four sheets.

(7.) Burma and Adjacent Countries. Photo-zincographed. Scale, 32 miles = 1 inch.

(8.) Atlas of India. Scale, 4 miles = 1 inch. Engraved.

(9.) Provincial maps. Engraved on the scale of 16 miles = 1 inch.

(10.) Standard sheets of the Topographical and Revenue Surveys on various scales from 2 inches = 1 mile to 4 miles = 1 inch. 1 inch = 1 mile is the standard.

(11.) District maps on various scales, usually 4 miles = 1 inch. Transferred to stone from the engraved copper plates.

(12.) Himalayan Route map. Scale, 32 miles = 1 inch. Engraved.

The Trigonometrical Branch Office, Dehra Dun.—Although the three branches of the Survey (Trigonometrical, Topographical, and Revenue) were amalgamated in 1877, it was nevertheless found convenient to maintain the Trigonometrical Survey Office at Dehra Dun, where important and special work had and still has to be transacted. The principal part of this work has been the final reduction and publication of the Indian and extra-Indian triangulation, both principal and secondary, which was carried out for years under the care of Mr. J. B. N. Hennessey and Mr. W. H. Cole. This Department has also had to publish the Topographical Surveys executed by the parties formerly attached to the Trigonometrical Branch, as well as those carried out by the Forest Survey Department. Being located at a considerable distance from Calcutta, the office has a small drawing, photo-zincographic, and printing establishment of its own, as well as a depôt of instruments and stores attached to it, chiefly of the higher class of instruments appertaining to the Great Trigonometrical Survey, such as several large theodolites, the compensation bars, and apparatus for the measurement of base-lines, &c. Other work pertaining to this branch has consisted in the determinations of azimuths from celestial observations at many of the stations of the triangulation; the observations of astronomical latitudes, the determination of differences of longitude by the aid of electric telegraph, and the determination of sea-level at many places on the coasts of India, from which main lines of spirit-levelling are

run over the country to form a basis for canal, railway, and other operations. Vol. I. of the general account of the operations of the Great Trigonometrical Survey was completed in 1870. In 1878 and 1879 Volumes II., III., and IV. were produced, giving a general account of the triangulation and its reduction, with full details of the North-West Quadrilateral; also Vol. V., giving an account of the Pendulum Operations; this was followed in 1880 by Vol. VI. for the South-East Quadrilateral, in 1882 by Volumes VII. and VIII. for the North-East Quadrilateral, in 1883 and 1887 by Volumes IX. and X. on the Electro-telegraphic longitude operations executed during 1875–77 and 1880–84, and in 1890 by Vol. XI. on the Astronomical Observations for Latitude made during the period 1805 to 1885, and Vols. XII. and XIII. on the Southern Trigon. Of the synoptical volumes—which give a précis of the results, both principal and secondary, for topographical and geographical requirements—twenty-three have been published in all.

In the volume on the Pendulum Operations it is shown that the steps which had been taken to connect the Kew Observatory, the base-station of the Indian operations, with the Greenwich Observatory, which was an important station of the European operations, had not sufficed to effect the desired connexion. The absolute length of a seconds' pendulum of the Kater pattern, which had been determined at Greenwich by General Sabine in 1831, was determined with the same pendulum at Kew by Major Heaviside in 1873, in the expectation that this would suffice for the connexion of the operations at the two observatories; but the result gave three more vibrations in 24 hours at Kew than at Greenwich, which was highly improbable, as it corresponds to a change in latitude of about 1°, whereas the two observatories are nearly in the same latitude and only ten miles apart. Colonel Herschel was therefore deputed to determine the vibration numbers at Kew and Greenwich with the invariable pendulums which had been used in India. He was also authorised to take the pendulum to America and swing them at some of the pendulum stations of the United States Coast and Geodetic Survey, with a view to a further connexion with the Indian operations. He made observations accordingly, employing the two Indian pendulums, and a third pendulum of the same pattern which he obtained at the Kew Observatory; he swung all three pendulums at Kew and Greenwich, in London, and at Washington and Hoboken in the United States. He then made over

the three pendulums to officers of the United States Survey, who took them round the world and swung them at Auckland, Sydney, Singapore, Tokio, San Francisco, and finally at Washington. When Colonel Herschel's observations came to be finally reduced, it was found that the relation of Kew to Greenwich by one of the pendulums differed by more than six vibrations from the values by the two other pendulums. Revisionary swings were therefore made at the two observatories, with all three pendulums, by the observatory staff at each place. The final result gives the daily vibration number at Kew an excess of 0·64 of a vibration over that at Greenwich. General Walker has given an account of Colonel Herschel's work and the revisionary operations at Kew and Greenwich, with an abstract of his results and those of the officers of the United States Coast and Geodetic Survey at other stations, in the Philosophical Transactions, Vol. 181 (1890) A., pp. 537–558.

At the Dehra office the solar photographs referred to at page 340 of the Memoir on the Indian Surveys, 2nd edition, were taken under the care of an observer, Mr. C. Meins, who had been trained by Mr. Norman Lockyer. Mr. Meins died on the 31st March 1879, and nine months later the observations were resumed by Mr. L. H. Clarke. The photo-heliograph employed gave 4-inch images of the sun, but by means of an enlarging combination, 8-inch pictures were obtained, while the definition in no way suffered. In July 1882, however, the great photo-heliograph sent out by the Secretary of State, and capable of taking 12-inch pictures of the sun, was received, and after some difficulty connected with the period of exposure, and some delay entailed by the construction of the necessary rotating dome, good and regular pictures were eventually secured. The difference between the amount of invisibility in India and in the sunless climate of England is very striking; in 1880-81 at Dehra Dun the percentage of dark days was 15; in 1881–82 it was 10, and in 1882–83 it was 13, as against 50, which was the average percentage of "invisible" days at Greenwich during the same period! The 8-inch pictures have been continued *pari passu* with the 12-inch photographs, the former being used for the measurement of the areas of spots and faculæ, while the latter are specially suited for the study of the mottling or granular appearances of the normal photosphere and structure of the penumbra of the spots. The results of the observations are included by the Astronomer Royal in the yearly volumes of the Greenwich observatory.

Successive editions of General Walker's excellent map of "Turkestan "and the countries between the British and the Russian dominions "in Asia" have been produced at the Dehra Dun office, the last (7th ed.) having been issued in 1885. At that time the surveys in connexion with the Russo-Afghan boundary were actually in progress, and since then our geographical knowledge of Afghanistan and the adjacent regions has been so revolutionised that an entirely new map has become necessary. But during the 20 years that Walker's map has been in existence it has been invaluable as the standard map of that vast and important region between the Caspian sea, the Persian gulf, and Tibet. A full and interesting account of the circumstances under which it was undertaken, and of its general construction, will be found in the appendix to the Report of the Trigonometrical Survey for 1872–73.

The new map of Afghanistan which will, to a great extent, take the place of the foregoing, embodies the surveys and reconnaissances made by the officers and native surveyors attached to the Afghan Boundary Commission. It is in four sheets and on the scale of 24 miles to the inch, and the work of preparation, first under Major Gore and then under Colonel Holdich, has been divided between the Calcutta and Dehra offices. Among other cartographical work that has devolved on the latter branch have been the three sheets illustrative of A—— k's remarkable explorations in Tibet,* and a two-sheet map of Arabia and Persia for the use of the Resident in the Persian gulf.

Another important duty devolving on the Dehra Dun branch is that of protecting the principal stations of the Great Trigonometrical Survey. In 1884–85 the number of these stations was 3,665, and their protection involved correspondence and accounts with a large number of district officers to provide for their repair.

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* *See* above, pp. 152–7.

XII.

GEOLOGICAL SURVEY OF INDIA.

From a geological point of view, India is most conveniently regarded as presenting a threefold aspect, and this is the general division of the country adopted in the "Manual of the Geology of India," *i.e.*, into the peninsular area, the extra-peninsular area, and the great Indo-Gangetic alluvial plain separating the two.

When we proceed to distinguish the various formations, we find that the geology of the country south of the Himalayas presents a comparatively simple aspect, in that all the rocks are easily separated into the following great groups, viz. :—

6. Alluvial plains.
5. Sedimentary rocks, of jurassic, cretaceous, and tertiary ages.
4. The Deccan basalt, of cretaceous and lower tertiary age.
3. The Gondwana system, comprising the Indian coal measures, and ranging inclusively from the age of the English coal measures to that of the Portland and Purbeck beds.
2. The Vindhyan system, a formation peculiar to India, the age of which cannot be guessed, as it has yielded no fossils, but which is immensely older than the Gondwanas.
1. The archæan or metamorphic rocks, such as gneiss and crystalline schists with the granite often occurring in them, and with some slaty rocks that have partially escaped the general metamorphism.*

Long before the establishment of an organised geological survey, a series of travellers had from time to time recorded observations of a practical or scientific character on the rocks and minerals of India. Foremost among these observers were Dr. Falconer and Sir Proby Cautley, to whom the discovery of the wonderful fossil fauna

* A detailed consideration of these formations does not come into the province of this book. It may be mentioned, however, that an excellent and picturesque general account of the Geology of India, from the pen of Mr. Medlicott, F.R.S., late Director of the Survey, is to be found in Sir Edward Buck's Statistical Atlas of India, while those who desire to pursue their investigations still further should consult the Manual of the Geology of India, in 4 vols. with map, Calcutta and London (Trübner).

of the Siwalik hills was due, a discovery which revealed the extraordinary nature of the animal life with which the alluvial valleys south of the Himalayas once teemed. Another famous geologist was Captain Newbold, who made some important researches on the laterite of the western coast, the regur or black cotton soil of the south, and the mineral resources of the country, while Dr. Carter, of the Indian Navy, in addition to his original investigations, collected and classified the recorded observations of his predecessors.

The first geological map of India was compiled by Mr. Greenough in 1853; and this forms a distinct landmark showing the state of our knowledge at that time; but it was not till 1856 that Lord Canning, who took a real interest in geology, placed this branch of the survey on a proper footing, under the superintendence of Dr. Thomas Oldham.

The excellent work of Dr. Oldham and his able assistants are described in detail in the publications of the Department, which are threefold, viz., the "Memoirs," "Records," and "Palæontologia Indica." The first-named are the detailed and matured results of the investigations in each district, written by the geologist who prosecuted the survey. The volumes are profusely illustrated with maps, views, sections, and sketches. The "Records" are issued quarterly, and contain the annual reports and brief abstracts of the results of the field work during the previous three months, as well as other papers of general interest. The "Palæontologia Indica" contain elaborate illustrations and descriptions of the organic remains which are discovered during the progress of the survey. A most interesting summary of the labours of the Department up to 1875 is contained in Chapter XIV. of the "Memoir on the Indian Surveys," at which period, in spite of the limited staff and the inherent difficulties of so vast an undertaking, an area about five times as large as Great Britain had been examined and reported on.

The year 1876 was one of special advance in the knowledge of Indian formations, for some problems previously unsolved or misunderstood in the classification of the great plant-bearing series of rocks known as the Gondwana system, the only fossiliferous formation of central peninsular India, was at last successfully grappled with by investigations and discoveries made by Mr. Hughes and Dr. Feistmantel, in the Pranhita valley, and corroborated by the researches of

Dr. King in the Godavari delta. An important gap in our knowledge of the Sub-Himalayan tertiaries was also filled up by the season's work. Messrs. Medlicott, Theobald, and Lydekker made an outline survey of the broad band of tertiary deposits flanking the Pir Panjal in the Jammu territory, thus connecting previous work in the Cis Ravi and Trans-Jhelam regions. In the east, in Upper Assam, Mr. Mallet completed his survey of the coal fields of the Naga hills, which for quality and quantity of the coal, rank as the most important of the Indian carboniferous deposits, although entirely of tertiary age, possibly even of middle tertiary.* On the south-west extension of the Sub-Himalayan series, Mr. Blanford, assisted by Mr. Fedden, accomplished a good season's work on the tertiary deposits in Sind. A preliminary sketch of these formations from the previous season's field work was published by Mr. Blanford in the "Records" for 1876 (p. 8).

Early in 1876 Mr. Blanford made an important trip across the desert east of the Indus, through Umarkot and Balmir to Jodhpur, and back through Jaisalmer to Rohri. Interesting information was thus gained regarding a great area of Western Rajputana, previously almost unknown, and of the region traversed by the Arvali mountains, a tract believed to be formed entirely of gneissic and transition rocks, the remains of an exceedingly ancient mountain system or area of special disturbance. The main difficulty here demanding solution is the occurrence within a moderately large area of several strong rock groups, having much mutual resemblance, and each independently in natural contact with a fundamental gneiss.

The survey sustained an irreparable loss during 1876 in the retirement of Dr. Thomas Oldham, F.R.S., the able and eminent superintendent, whose services will be found briefly recorded in the Memoir on the Indian Surveys. He was succeeded by Mr. H. B. Medlicott. Mr. Tween, the chemist to the survey, also retired, after a service extending over 15 years.

A first-class medal was awarded for the exhibits of the Geological Survey of India at the Congrès International des Sciences Géographiques, held at Paris in 1875.

During 1877 two comparatively new regions were explored by Mr. Lydekker and Dr. Ball, respectively, one being the mountains

* *See* Part 2 of the Memoirs of the Geological Survey of India, Vol. XII.

north and south of the Kashmir valley and in the upper basin of the Chenab, and the other a wide tract some 300 miles long between the Mahanadi and the lower reaches of the Godavari. The former was rather difficult ground; the presence of carboniferous strata had long since been observed, as well as the extensive occurrence of eruptive rocks; but the relations of all these to the preponderating mass of contiguous unfossiliferous rocks had remained unknown. Mr. Lydekker showed that the Kashmir area is a compressed synclinal ellipse, on the pattern of the larger features defined by Stoliczka in the Tibetan region, but containing, so far as observed, no rocks younger than the trias. Regarding the obscure point of the relations of the gneissic series, Mr. Lydekker's view was that the Pir Panjal range is on the whole a great folded anticlinal flexure, having a cone or axis of gneiss, the whole stratified series on the outer (south-west) side being inverted. The Simla region, which belongs to the broad area of lower mountains which east of the Sutlej separates the snowy range from the plains, is made of metamorphic and slaty rocks, in a very irregular and incomprehensible mode of distribution. This region was examined by Colonel McMahon, himself an amateur geologist, and his paper is published in the "Records." He shows that the massive gneiss forming several prominent ridges on the lower mountains must be the same as the central gneiss of the main range; he describes the upper members of the slate series to be so related to this gneiss as to involve the total overlap of the lower part of the series, and therefore complete unconformity to the gneiss, but subsequent metamorphic action, largely affecting the slate series itself, has so obscured the junction as to make the exact definition of it a matter of great difficulty.

The region between the Mahanadi and the Godavari is a wild, hilly country, entirely occupied by primitive tribes and petty tributary states. It proved (as indeed had been conjectured) to be occupied by Vindhyan and gneissic rocks. On the coast side there is a broad mountainous belt of crystalline rocks, with peaks exceeding, in some cases, 5,000 feet in elevation. West of this is an extensive upland also largely formed of gneissic rocks, upon which stand two or more scarped plateaux of flatly bedded sandstone, the principal being that of Nowagarh-Kharial. Further west there is the wide expanse of lower ground formed of the shales, limestone, and sandstones occupying the plains of Chattisgarh and

Upper Mahanadi, and stretching southward to the more elevated land about Bustar. High-level laterite was also found, giving a plateau character to the otherwise serrated mountain features.

Mr. Hacket's work in Rajputana also ranked as in new ground. He carried his observations to some distance south of Ajmir, where he obtained a further section of the metamorphic rocks transitionally underlying the Arvali series.

The recognition of the Karharbari coal measures as a distinguishable horizon in the lower Gondwana series was an interesting step in the knowledge of these formations. Dr. Feistmantel's palæontological researches indicate that their affinity is rather with the Talchirs than with the Damudas as hitherto imagined.

Among the detailed work of the year, an interesting area of the Gondwana formations was completed by Mr. Hughes, in extension of his previous work in the Wardha valley, the geological lines being carried down to the Godavari at and above Sironcha. A practical result of this work was the accurate demarcation of a considerable area of possibly productive coal measures in the Nizam's territories about Khairgura and Tandur, and again on the Godavari at Sandrapali. In the former position actual coal crops were found, and in the latter promising indications of the same formation.

Mr. Foote, during the season, completed his survey of the coastal zone of Gondwana deposits through the Nellore and Gantur districts up to the Kistna river, thus bringing his lines into connexion with Mr. King's work in the Godavari district south of Ellore. The deposits which were the special object of his study are very obscurely exposed as irregular patches along the margin of the crystalline rocks forming the low ground from the base of the Eastern Ghâts, and on the east they pass rapidly under the alluvium of the flat seaboard. Mr. Foote has made considerable collections of the mixed marine and terrestrial fossils peculiar to the Gondwana strata in this position.

The coal explorations which had been prosecuted for some seasons past in the Satpura basin unfortunately proved unsuccessful, though in some cases the borings were carried to a greater depth than anywhere else in India.

Some observations on underground temperature in these borings were instituted by Mr. Medlicott. The lowest depth at which successful observations were taken was 370 feet, and the most

reliable group of these at Manegaon gave, below the depth of 60 feet (throughout which a constant temperature of 81° prevails) a very steady rate of increase of 1° Fahrenheit for every 66 feet in depth.

Mr. Wynne was fully occupied in mapping the structural features of the tertiary basin between the Salt Range and the mountains to the north, which is often spoken of as the Potwar or Rawalpindi plateau. It is on the whole a broad synclinal with many subordinate axes of flexure, and the disturbed character of the deposits makes their study a matter of great difficulty. The post tertiary deposits here are of much interest. They are found resting upon tilted Siwalik strata at very high levels over the actual river courses, so that prodigious denudation must have taken place since they were laid down. There is much evidence to suggest that glacial action took a direct part in the accumulation of some of these deposits.

During the working season of 1876–77 Mr. Blanford and Mr. Fedden completed the mapping of Sind west of the Indus. The former re-examined the Khirthar range from its northern termination west of Jacobabad to the neighbourhood of Sehwan; he then re-mapped the cretaceous rocks in the Laki range south of Sehwan, and after completing the geological lines in the Habb valley, and marching westward along the coast as far as Sonmiani, returned to Calcutta. Mr. Fedden, starting from Karachi, mapped the large tract of country west of the Laki range from the neighbourhood of Sehwan to the sea, an area of nearly 5,000 square miles. Large additions were also made to the fossil collections previously obtained. So much of the geology of Sind had been determined in the two previous seasons that no very important addition could be expected. It was, however, clearly ascertained that a band of contemporaneous volcanic rock, from 40 to 90 feet thick, intervenes between the base of the Ranikot group (lower eocene) and the cretaceous beds, and there can be little doubt that this thin lava-flow represents the great mass of the Deccan traps.

Mr. W. T. Blanford's memoir (Vol. XVII., Art. 1) on the geology of Western Sind* deals with that portion of the province

* The names of the province of Sind and of the river called the Indus by Europeans are really identical, and Hindu, Hindustan, and India are all derived from the same source, the letters S. and H. being interchangeable. The old name of the Indus is Sindhu. There is a Muhammadan story about the name of Sind being derived from Sindh, the brother of Hindh and son of Noah.

of Sind which lies west of the Indus, and especially the hilly portions of the Karachi and Shikarpur collectorates, together with the curious isolated ranges of limestone hills to the east of the Indus in Northern Sind near Rohri, and in Southern Sind near Haidarabad. The examination of the geology of the province was a special desideratum as the peninsula of India has had a very different geological history from other parts of the country, the former having probably been land ever since palæozoic times at least, while the extra-peninsular regions have frequently been covered by sea. Fuller series of marine tertiary beds were known to exist in Sind than elsewhere in India, and other advantages lay in the absence of forest which so greatly impedes surveying, and in the circumstance that large collections of fossils from this region have been carefully examined and described by European palæontologists. Sind is also nearer to Europe than most parts of India, and the rocks form the eastern prolongation of a tract of tertiary beds believed to be continuous with the well-known formations on the shores of the Mediterranean. The Khirthar group, named from the great frontier range of hills, comprises by far the most conspicuous rock, the massive nummulitic limestone, of which formation all the higher ranges in Sind consist. The sections exposed in the Khirthar range are superb, and afford the best epitome of tertiary geology hitherto observed in India. Above is found the Nari group, occupying a belt of varying width from one to ten miles in breadth throughout the eastern flank of the Khirthar range; the lower beds of this group are mostly yellow or brown limestone, while the upper series assume the form of coarse, massive, thick-bedded sandstones, attaining in some places a thickness over 4,000 feet. Upon the Nari group, almost throughout Sind, is found resting a mass of highly fossiliferous limestones and calcareous beds (the Gaj group), easily distinguished from the limestones of the older tertiary formations by the absence of nummulites, while the highest sub-division of the Sind tertiary series, the Manchhar group, represents in all probability the well-known Siwaliks of Northern India, consisting of clays, sandstones, and conglomerates, and attaining in places a thickness of about 10,000 feet. Westward of the British frontier the Manchhar beds die away, and are succeeded by high hills of hard greyish-white marls or clays, conspicuous at Ras Malan, Ormara, Pasni, Gwadar, near Jashk, at the entrance to the Persian Gulf, and on the Persian shores of the gulf itself. The headlands of Ras Malan, Ormara,

and Gwadar consist of great horizontal plateaux surrounded by cliffs of whitish marl or clay, and capped by dark calcareous grit. These remarkable rocks have been called the Makran group, and though the coast of Baluchistan has never been examined geologically, there appears a considerable amount of probability that the marine Makran group may represent the Manchhars and Siwalikhs on the edge of the Indo-Gangetic plain.

The completion of the "Manual of the Geology of India" was the principal event in 1878. Though not the first general description of the Geology of India it differed from most previous works in the extent of the area described and the amount of information. Since the establishment of the survey in 1851, data in the shape of detached papers and reports had been accumulating rapidly, and these were not even confined to the official channels of publications but had overflowed into the journals of various scientific societies throughout the world. There was thus an urgent need of a general view of the existing knowledge, and Mr. Medlicott and Mr. Blanford's efforts supplied the want. While the work itself is a joint production, each chapter bears the initials of its actual author. The first two volumes deal with the more strictly scientific side of Indian Geology, while a third volume of over 600 pages from the pen of Mr. Valentine Ball treats of the Economic Geology of the country, its Mineralogy being described by Mr. F. R. Mallet in the fourth and last volume. A map on the scale of 64 miles to the inch and geologically coloured forms a valuable accompaniment to the work.

During the same year Mr. Hacket examined a very large area at the northern extremity of the Arvali range, and extending up to the Jumna at Delhi. Though not abundant in mineral wealth the Arvali region contains several extensive mines, now abandoned, from which in bygone times large quantities of copper and lead ores have been extracted, and a number of small pits or burrows where ores in small quantities were found. None of these mines, however, were worked deeper than a few feet below the water level on account of the difficulty of raising the water. Marble is of frequent occurrence among the Arvali rocks, and is extensively quarried in several places, the principal place being Makrana. It is generally white, but coloured marbles are occasionally met with, and black marble in one spot.

A description of the previously unsurveyed basins of Palamau was given by Mr. Ball in Vol. XV. of the Memoirs.

Palamau had attention directed to it about 60 years ago, when the object was to open out the coal-fields then known to exist, and so to obtain a supply of cheap fuel for the steam navigation of the Ganges. To meet this demand the Daltonganj field was worked by the Bengal Coal Company up to the time of the mutiny, when the works were attacked by the rebels and destroyed. On the completion of the main canal, the question of connecting the Palamau fields with the East Indian railway arose, and an examination of the coal and iron ores available became necessary. Mr. Ball speaks highly of the coal from the Daltonganj field, which has great heating power and is admirably adapted for steam purposes; that from the other two fields of the Palamau basin, the Aurunga and Hutar, being of only average quality. The Aurunga field is, however, the only locality where there are iron ores and limestone suitable for iron manufacture.

The Rajmahal hills, which are described by Mr. V. Ball in Vol. XIII. of the "Memoirs" are of complex geological structure, but the mutual relations of the several rock groups within their limits have supplied a useful key to the geological problems of far distant localities. Amongst other notable features in this area are some curious examples of radiating columnar trap,* while at least two varieties of laterite occur. The coal found is inferior to that of a large series of Raniganj coal, but it can be easily worked, though the difficulties and cost of transit to rail and rivers render it unavailable except to stations in the immediate neighbourhood. A considerable variety of rocks suitable for building purposes exists in the Rajmahal hills, while the basaltic trap is capable of affording an inexhaustible supply of road material. Clays suitable for pottery and iron also occur.

The geology of the district of Manbhum, which lies about 120 miles west of Calcutta, and of Singhbhum, which is situated to the south of Manbhum, is also described by Mr. V. Ball (in Vol. XVIII. of the Memoirs). The tract abuts on the headlands (as they may be called) of the eastern frontier of the rocky and elevated country of western Bengal, the headlands themselves being lapped round by the Gangetic alluvium, which spreads over Lower

* *See* illustration facing page 60, latter part of Vol. XIII. of "Memoirs of Geological Survey of India."

Bengal. The northern part of the region is occupied by metamorphic rocks, which pass across the boundaries of Manbhum on the north into Birbhum and Hazaribagh, on the west and south into Lohardaga and Singbhum, and on the east into Bankura and Midnapur, while the southern half is covered by sub-metamorphic rocks, the term adopted by the Geological Survey of India for a series which, though showing distinct signs of metamorphism, do so in a much less degree than do the gneissose or metamorphic rocks proper. The prefix *sub* refers to the amount of metamorphism, not, as might be supposed, to the position in the geological scale. Speaking generally, the sub-metamorphics of Bengal may be said to occupy a position in the geological scale roughly corresponding to that of the Huronian of Canada or the Cambrian of Europe.

The determination of further obscure points in the great Gondwana series occupied the attention of several members of the Geological Staff in 1878. Dr. King was engaged in endeavouring to fix the middle Gondwana horizon on the lower Godavari, while Mr. Hughes came across plant fossils of decided upper Gondwana type between the Pranhita and Godavari rivers. Early in the season Dr. Feistmantel visited the Satpura coal basin to examine on the spot some good sections of the Gondwana series. He shows that they belong to the horizon of coal-bearing strata represented by the Karharbari measures in Bengal. And on the western confines of the Peninsula, where the Gondwanas become associated with marine strata, Mr. Fedden broke new ground in Kathiawar, of which he surveyed about 1,800 square miles. He speaks very highly of the excellence of the sheets of Captain H. Trotter, R.E.'s Topographical Survey of that province. The country is for the most part flat, and the rocks consist of Deccan traps overlying sandstone in which some remains of plants were found. These plants prove to be identical with those occurring in the uppermost jurassic or Umia beds of Cutch, and it is thus clear that a portion at least of the Cutch jurassic series extends into northern Kathiawar. The greater part of the area examined consists of jurassic sandstone, the hills being of trap, but to the southward, where the surface is more hilly, the traps cover the country.

In Southern India Mr. Foote took up new ground to the south of Trichinopoly. The region belongs partly to the Madura, Tanjore, and Trichinopoly districts, and partly to the native state of Pudukotai or Tondiman. It may be described as a gently undulating inclined

plane, rising very slowly westward from the delta of the Cauvery or the sea board. It is only on the western part that the surface is broken by a few low but steep hills rising in the gneissic area and by the lines of scarp corresponding generally with the western boundary of the lateritic formations, which occupy by far the greater part of the country now under consideration. The district is poor in economic minerals. In the extreme North-western Punjab Mr. Wynne made a preliminary examination of some new ground in Hazara, having been prevented by difficulties on the frontier from following the formation of the Salt range across the Indus into Bannu as had been proposed. He made a useful reconnaissance of the ground and defined the limits of the crystalline rocks forming the higher mountains. One general inference was that the gneiss of Hazara is much newer than the central gneiss of the Himalayas. Mr. Lydekker's work in the N.W. Himalayas was much hindered by the famine in Kashmir, so he spent the season in the mountains of Dras and Tilail where he described some important sections of the sedimentary rocks. Colonel McMahon also made some noteworthy observations in the Central Himalayan districts to the north of the Simla region of the Lower Himalayas, on the relation of the limestone and slate series of the latter range to the central gneiss. Mr. Theobald made large additions during the same season to the collections of Siwalik fauna, the results of which are recorded in Mr. Lydekker's papers in the Records and the "Palæontologia Indica."

Mr. Mallet was deputed to report upon some coal seams in Ramri Island, which had been reported by the Commissioner of Akyab. Mr. Mallet could not form a favourable opinion of the practical value of these measures; the coal is inferior to that of Bengal, and the measures are greatly disturbed and would be difficult to work. Specimens of a very different coal, a bright jetty lignite, were forwarded by the Commissioner from the Baranga islands. Mr. Medlicott also made a short trip to the North West Provinces to serve on a committee appointed for investigating into the causes of deterioration of land by *reh* or efflorescence in the Aligarh district. His notes were published in the report of the committee.

Two large parts of the Palæontologia Indica were issued during the year, one by Dr. Feistmantel on the flora of the Jabalpur group, containing 14 plates, and one by Mr. Lydekker on the crania of fossil ruminants, containing 18 plates. By order of Government

the price of these publications, and that of the "Records," were lowered.

During 1878 the survey lost Mr. Walter Lindsay Willson, who died on the 23rd of March 1878. He had joined the Indian service in March 1857, having at that time been for some years Senior Geologist on the Geological Survey of Ireland; the training he had there received was very marked in the finished neatness of his field maps in India. His place was taken by Mr. C. L. Griesbach, F.G.S., who was appointed by the Secretary of State in the latter part of the same year.

The great tract of Gondwana rocks, occupying the lower half of the Godavari valley, is conveniently divisible into two areas, separated physically by that portion of the Eastern Ghats sometimes called the Golconda range of mountains, and geologically in that the upper division of this formation is in great part of marine origin to the south of the hills, while there are only river and lacustrine members of the series in the upper part of the valley. The portion below the Ghats, or in other words the coastal region corresponding to the lower division of the Godavari district, is described by Mr. King in Vol. XVI. of the "Memoirs." The country mainly consists of the deltaic deposits of the Godavari and the Kistna, rising gradually amid groups of small hills up to the Kaurkonda-Papakonda range. It is a puzzle how the Godavari river came to cut its way down through a 2,000 feet high range of crystalline rocks (where the famous "gorge" of the Godavari lies), when it might have deviated and flowed through the more easily worn sandstone to the south-west near Ashwaraopet, where the great gap (crossed by the Kistna) in the continuity of the Eastern Ghats commences. The economic geology of this region is of no great importance, though old diamond workings exist in the sandstone near Muleli, west of Ellore.

In 1879, Mr. King's researches were prosecuted among the Gondwana rocks in the Pranhita-Godavari area, and the detailed account is contained in Vol. XVIII. of the "Memoirs." The Godavari valley for a considerable length of its lower course traverses a great area of Gondwana rocks, which connects the Nagpur or Kamthi and Chanda fields of these with the patch of the same great formation on the Coromandel coast. The Chanda rocks extend southward by the Wardha river valley, and so with the Pranhita river to its junction with the Godavari, whence they are

continued down the valley of the latter river, and it was in the following out of this great series of the plant-bearing sandstones with the economically interesting coal measures of their Damuda subdivision that this immense tract of wild and poorly populated country came to be visited by the survey. The Pranhita-Godavari area is thus a narrow strip of Peninsular India, extending from about Dhaba or Porsa on the Wardha in a S.S.E. direction to within 40 miles north of Ellore. With the exception of the bottom or floor rocks, namely, the gneiss or crystalline series, which extends far to the eastward and westward, all the other formations occur as roughly parallel outcrops or bands. It is still practically what it has been for ages, the home of a great portion of the old Pre-Aryan race of Kols or Gonds, and a centre for the huge trains of grain- and salt-carrying pack bullocks of the Brinjaris, who find the region well adapted for their temporary settlements and feeding grounds. Judging, however, by the ruins of many large forts, splendid temples, and great tanks scattered over part of the country, the Aryan conquerors exercised there a benign and prosperous sway.

The better known outcrops of Barakar strata showing workable coal of any value are in the southern part of the above field, at Damerchela, Lingala, and to the westward in the two fields of Kamawaram and Singareni.* Iron is obtained from the Chikiala sandstones, and gold in small quantities has been washed for, having been found to be brought down into the Godavari by streams from Haidarabad territory.

An irregularly shaped strip of the Carnatic, including rather more than the southern half of the Nellore district and portions of the northern edges of those of Madras and North Arcot, was traversed by Mr. W. King and the late Mr. Charles Æ. Oldham in 1861, while following out the transition rocks of the Cuddapah district. Mr. King's account was written subsequently† and after Mr. Oldham's death. The region is in the nature of a coastal plain with a more or less distinct step or ghât edging an upland, the former being of gneiss, covered up in a scattered way (more perfectly towards the coast) by later formations, while the western hill wall is of

* A report on the progress and results of borings for coal in the Godavari valley near Damagudem and Bhadrachalam, by Mr. W. T. Blanford, forms an Appendix to Vol. XVIII. of the "Memoirs."

† *See* "Memoirs," Vol. XVI.

the hardest rocks of the transition or Cuddapah series. The carving out of the great plain and step of mountain wall was evidently in the greatest measure the work of marine denudation, though subsequent atmospheric and river degradation and later deposits have obliterated most traces of this. An interesting feature observable in this region is a narrow and low sandstone ridge, from 40 to 70 feet above sea-level, with a lateritic covering running generally north and south at from 10 to 20 miles inland from the sea shore, and forming an extension of the Red Hills of Madras, Pondicherry, Cuddalore, and Samulcotah in the Godavari district. This plateau ridge marks what may be considered the last permanent upheaval of the Coromandel, but the views of the Survey differ as to the period when this may have taken place, Mr. Foote inclining to date the upheaval during the human period, while Mr. King is doubtful whether it can be fixed so late.

The eastern coast from latitude 15° and northward to Masulipatam is described by Mr. Foote in Vol. XVI. of the "Memoirs." The topography is simple, consisting as it does of an inclined plane sloping gently eastward from the foot of the Eastern Ghats to the Bay of Bengal, diversified only by scattered hills. Fiscally the area is divided between the Kistna and Nellore districts. The geological structure is almost as simple as the topographical, the western part being occupied by a broad band or zone of ancient crystalline rocks belonging to the gneissic series, the eastern part by marine and fluviatile alluvia, while the intermediate part, roughly speaking, is occupied by a band of patches of sedimentary rocks of two ages, both older than the alluvial formations. The economic resources of this region are very small as regards all the really valuable and important minerals; there is a great deal of good iron ore, but unfortunately no coal or mineral fuel accompanies it, while in the matter of building and road materials, the supply, though plentiful, is no better than the average districts further to the south.

Mr. Foote's exhaustive description of the geological features of the South Maratha country (*i.e.*, the country which formed the southern part of the Maratha empire without reference to the distribution of the Maratha people) is published in Vol. XII., Part I., of the "Memoirs." Although a very large portion of this area is inhabited by Kanarese people, who differ very widely in appearance and language from their Maratha neighbours, the term is a convenient one for the irregular belt stretching from near

Haidarabad in the Deccan to the western coast between Ratnagiri and Goa. Of the several rock series found there the gneissic is the mostly widely developed, and occurs chiefly in the eastern, southern, and south-western parts of the area, while the Deccan trap covers very nearly as large an extent of ground in the western and northern parts. The iron clay or lateritic beds cover a much smaller area, but claim notice on account of their remarkable features. They cap all the highest ridges and peaks in the Kolhapur and Belgaum mountains, rendering them perfectly table-topped, and in consequence favourite sites for old Maratha strongholds and forts.

In continuation of Mr. Ball's survey of the Aurunga and Hutar coal fields (*see* "Memoirs," XV., Parts I. and II.), Mr. Griesbach, during 1879, mapped and described some 900 square miles of Gondwana rocks in Ramkola between Takapani and the Rer river. The ground is the easternmost prolongation of the great central area of South Rewa or the Son, extending westwards to near Katni on the Jabalpur railway and south-eastwards into the Mahanadi basin to near Sambalpur. In Kathiawar, on the southern confines of the Arvali metamorphic region, Mr. Fedden completed the survey of some 1,900 square miles in continuation to the south of his previous season's work, besides making some preliminary traverses of adjoining ground. Nearly the whole area is occupied by the great eruptive formation. It is mostly stratified, having a slight inclination to the south, but huge dykes traverse it in various directions, forming prominent ridges across the low undulating country. The isolated central hill forming the sacred peak of Girnar is a mass of thoroughly crystalline rock, which seems to be the core of a volcanic focus. Owing to the scattered position of the outcrops in a wide-spread waste of sand, Mr. Hacket was enabled to add a very large area (more than 10,000 square miles) to his previous study of the Arvali region, extending to the south-west as far as Erinpura. The Vindhyan strata were found to cover a large area to the north and east of Jodhpur; they everywhere rest flatly upon the old rocks, the gneiss, schists, felsites, or Alwar quartzites.

With the aid of the new maps of Kumaun, Mr. Theobald explored the belt of tertiary rocks at the base of the mountains between the Ganges and the Kali, in continuation of the work done several years previously to the west of the Ganges.

Mr. Wynne, besides making a reconnaissance of the ground far to the north between Kohat and Thal on the Kuram, accomplished the

survey of the western extension of the Salt range from the Indus to the outskirts of the Suliman range beyond Shakh Budin. The Salt range proper, or eastern section, between the Indus and Jehlam rivers, had been examined by Mr. Wynne in 1869-70, with the assistance of Dr. W. Waagen, for the palæontology, but the report was not published till 1878, when it appeared as Vol. XIV. of the "Memoirs," forming a volume of over 300 pages. The range had long been known as one of the most interesting and important regions in British India, its geological interest being enhanced by its highly fossiliferous rocks, and its importance chiefly derived from its enormous deposits of rock salt. Years before the British conquest of the Punjab, our officers penetrated thither and reported on the geology of the region. In making a detailed examination, Mr. Wynne had the advantage of the excellent maps constructed by Captain D. G. Robinson, R.E., one of the best set of maps ever produced in India.* The Salt range occupies historic ground, one extremity resting upon the ancient Hydaspes or Jehlam river, the other on the Indus, while its eastern extension overlooks the battle field of Chilianwala, which is marked by a memorial obelisk built of materials taken from the range. The Mayo mines in the eastern plateau of the range are probably the most extensive salt mines in the world. Old chambers occur in them up to 320 feet in width and 130 feet in height, besides natural shafts formed by rain water, one of which is 312 feet deep. The old workings had long been in a dangerous condition, and disastrous falls have taken place—one in 1870. When visited in 1869-70 the position of the miners was anything but enviable, perched upon a lofty tripod of slender sticks and picking at a roof full of fissures and unsupported for many yards. The colour of the salt is red and white, red earthy or merely coloured layers being very numerous in some of the beds. The main mass of the gypsum overlies the salt, and is succeeded by the purple sandstone and other groups in their proper order. The Salt range geology is peculiar and differs greatly from that of neighbouring countries, so far as they are known, comprising as it does various consecutive palæozoic, mesozoic, and tertiary formations, and even including among the older rocks a group of Silurian age. Nevertheless, there is a remarkable degree of continuity preserved throughout the deposits. The range thus forms a continuous series, embracing alternations

* *See* Mr. Markham's notice of these maps, p. 121 of "Memoir on the Indian Surveys," (2nd Edition).

of calcareous, earthy, and arenaceous deposits, chiefly marine, but possibly in part of fresh water origin—a series comprising thirteen main divisions, of which nine are distinctly referable each to one of the thirteen principal formations known to geology, and the ages of four are less accurately ascertained. The development of the whole range is not at any place complete, the groups changing along their outcrop in thickness if not also in character; from the fourth to the seventh group in ascending order the series extends westwards across the Indus.

For the four years ending 1871 the receipts of the Inland Customs Department were Rupees 38,81,440 per annum, and as the rate at which the salt is sold at the mines is Rs. 3.1 per maund, an idea may be formed of the out-turn. Notwithstanding the enormous waste that goes on, especially in regard to carriage, the salt being reduced to rough spherical lumps to prevent the corners being rubbed off during its transport in open nettings or hair cloth bags, the supply seems practically inexhaustible. Coal is also found in the range, the Kalabagh coal or lignite, which is of jurassic age, being the best, as well as petroleum, building and ornamental stones, and gypsum.

The trans-Indus extension of the Salt range is also described by Mr. A. B. Wynne, in Vol. XVII. of the "Memoirs." Its geological structure repeats in a great measure that of the western portion of the Salt range proper, but with some important differences, the purple sandstone, for instance, of the latter disappearing at Kalabagh. Kalabagh itself is an interesting place, which has always attracted the attention of visitors. It is thus referred to by Thorburn, who states that the town was devastated by the Indus, on the western bank of which it is situated, in 1841 :—

"The houses rise one above the other on the hill side, nestling close packed in an abandon of dirt and confusion amid the glistening carnation-coloured salt of the rocks. It has a municipality and an old standing grievance: for as Government levies a duty of about 8*s.* 4*d.* on every hundredweight of salt quarried in the range, and as half the town is built of salt and on salt, the people are fined heavily should they attempt to eat their houses; and their cattle, when they loiter by the way in order to lick the rocks or the house walls, are ordered to move on by stern-visaged constables whose mud and salt-built sentry-boxes are perched about on every commanding knoll."*

Both orographically and geologically the Salt range is continued through the trans-Indus of the Bannu and Derajat districts to the Suliman mountains, both sections including with many variations palæozoic, mesozoic, and cainozoic formations. The salt all belongs

* "Bannu," p. 8, note.

to the same horizon as that of the Salt range proper, alum also occurs and is manufactured from the pyritous shales of the jurassic and eocene formations, but the industry seems to have greatly fallen off.

During 1879 Mr. Lydekker explored a large area of Ladak to the east of his previous observations and determined several points of interest, while Mr. Griesbach accomplished a very successful season's work in the higher Himalaya of Kumaun and Hundes, and despite the severity of the climate prevailing at this altitude succeeded in mapping the snowy range between the Niti and Milam passes.

The Records for 1879 contained 22 papers of various interest with 11 maps and plates, two being articles by contributors not attached to the survey; that on Hangrang and Spiti by Colonel McMahon, and that on the old mines at Joga on the Narbada by Mr. G. T. Nicholls of the Civil Service. Four parts of the "Palæontologia Indica" were issued during 1879, one by Dr. Feistmantel on the flora of the Gondwana outliers on the Madras coast, and another by the same author on the flora of the Talchir-Karharbari beds, one by Mr. Lydekker on the Reptilia and Batrachia of Indian pretertiary formations, and the first part of the Salt range fossils by Dr. Waagen.

Mr. Richard D. Oldham, the son of the founder and successful director of the survey, was appointed by the Secretary of State as an assistant in the survey, and took up duty with Mr. King in the Godavari valley. The two native apprentices, Kishen Singh and Hira Lal, having served their five years of probation with sufficient credit and having acquired a serviceable knowledge of rocks and minerals, received, on the recommendation of Mr. Medlicott, permanent promotion as sub-assistants.

In 1880 Mr. C. L. Griesbach was sent to the Bolan pass and Southern Afghanistan to report on the gold near Kandahar and the petroleum traces near Sibi. The first task was, however, much impeded (though eventually accomplished) by Ayub Khan's revolt, and Mr. Griesbach had to perform military duties for a time, after which the rising of the Marris prevented his visiting the petroleum locality at all, lying as it does 40 miles east of Sibi.

Mr. Griesbach is certain that the hills between the Indus plain and the Quetta valley are simply a continuation of the Kirthar range, already described by Mr. Blanford in his geology of Western Sind, while the range of hills which in turn bears the

name of Suliman range, Marri hills, Brahuik and Khirthar ranges, all form links of one great chain with a uniform geological structure. Speaking generally, the area examined on this occasion by Mr. Griesbach can be grouped into three divisions, viz. :—

1. The Brahuik area of Baluchistan, coinciding with the limestone facies of the older tertiaries;
2. The Pishin valley, with its eastern and western ranges (Ghaziaband and Khojak) falling in with the sandstone and shales (flysch) facies of the eocene group; and, lastly,
3. The Kandahar and Shah Maksud ranges are formed of cretaceous limestone and eruptive rocks of the same age.

Of special interest are the vast deposits of aërial origin, which not only cover extensive tracts of country in the great deserts of Registan, Seistan, &c., but also encroach rapidly on the more fertile plains of Southern Afghanistan, the valleys of the Helmand, Argandab, the lower Khakrez, and the great tracts lying between Kandahar and Quetta. The great deserts are formed of huge accumulations of blown sand and other material, among which a fine densely red clay is conspicuous. South of Kandahar this loose material, constantly changing its position, is seen to surround and creep up into the hollows, creeks, and fissures of the jagged cliffs of limestone and trap. Every season material is thus added, and the time must come when the whole Kandahar valley will be covered by this deposit and be merged into the endless expanse of desert to the south.

The gold near Kandahar occurs about three miles north of the city in quartz veins, between the hippuritic limestone and the extensive trap outbursts.* During the first months of the British occupation the gold was obtained in considerable quantities by a native contractor, who rented the mine from the Kandahar Government. Apparently, the process of extracting the gold with mercury, though rude, was paying, but the native workers, being ignorant of all engineering science, went on blasting the rock with gunpowder and sinking the shaft lower and lower, until the sides fell in and buried the miners below. Part of the auriferous vein is still visible, and about two inches thick, but Mr. Griesbach was told that it thickened lower down to about two feet or more, and some of the nuggets of gold obtained were of the size of a man's fist. He considers it highly probable that gold will be found all along the line of trappoid beds, north and west of the city, but the then disturbed

* Described also at p. 30 of Bellew's Seistan Mission, Calcutta, 1873.

state of the country frustrated any effort on his part to test the rocks. Gold is also found and worked in some fashion in the Hazarah country and in various streams of Northern Afghanistan.

Among other minerals found in Southern Afghanistan may be mentioned copper, which is worked in the Shah Maksud range, lead and antimony ores, argentiferous galena, and native silver, sulphur, petroleum (east of Sibi, since examined and reported on), coal, and gypsum. From olden times Kandahar has been celebrated as a market where precious stones were sold to the merchants coming from Shikarpur, but apparently only varieties of chrysolite and chrysotile with some cornelian are actually found there, both being derived from the amygdaloidal variety of the traps.

Mr. Blanford was officially deputed by the Government of India to represent the Indian Geological Survey at the Congress held at Bologna in 1881. This Congress had originated in a meeting of geologists of various nations at Buffalo in 1876, who, in their turn, arranged for an International Geological Congress at Paris in 1878, for the purpose of deciding upon rules for the construction of geological maps and for geological nomenclature and classification. Out of this second meeting arose the Bologna Congress of 1881, to which the questions at issue were referred, and which was attended by about 200 members, of whom 130 were Italians and 70 foreigners. On the whole, it cannot be said that much was done towards the unification of nomenclature, or of the colouring and signs for geological maps. It is an obvious drawback to congresses of this character that they are not strictly representative, and that their resolutions can have no binding force on absentees or dissentients. But it is very profitable to gauge, however tentatively, the general feeling of an important scientific body, and to those who have to pass most of their lives in remote regions like India, it is of vast importance to meet fellow-workers in similar fields and to exchange ideas.

One of the most important events in 1882 was the proving of the new coal field of Umaria,* at the west end of the South Rewa Gondwana basin. The actual area of exposed coal measures is small (about five square miles) in an angle between the gneissic rocks and the great spread of newer Gondwana sandstone to the north-east. The outcrop of coal had been known for many years, but its surface appearance was unpromising. An extensive field was thus opened to enterprise, Umaria being the nearest possible source of

* Noticed by Mr. Hughes in the "Records" for 1881 (Vol. XIV., Part 4).

coal for the North-Western Provinces, and immediately west of the immense coal field of Sohagpur, which district is also rich in agricultural produce, and the natural entrepôt for the surrounding forest tracts, while southwards from Sohagpur lies the least difficult line of communication between northern and southern India, into the plains of Chattisgarh, leading down the Mahanadi valley to Cuttack, and up it over the plateau of Bustar to Vizagapatam. Again, an opportunity was also offered for successful iron manufacture, there being probably no spot in India where such an abundant supply of first-class iron ores exists as at Katni, on the East Indian Railway. A survey for a line from Katni to the coal field was commenced. The Shapur coal borings in the Satpura region proved unsuccessful, but the cretaceous coal field of Darangiri, in the Garo hills, reported on by Mr. La Touche during the preceding season,* proved good, the quantity being very considerable and the quality serviceable.

Mr. Foote was engaged in Madura and Tinnevelli, principally in completing his map of the coast region and joining this work on to Dr. King's in Travancore. Mr. Hacket took up work in the wilder parts of the Arvali range in Southern Mewar, but being warned by the Political Agent of the hostility of the Bhil tribes, he employed the rest of the season very usefully in examining some intricate features along the Vindhyan boundary north-east of Neemuch. In Kathiawar a large area along the coast region, from Bhaunagar to Madhapur, consisting mostly of trap and post-tertiary rocks, with a remnant of tertiary beds on the western sea-margin, was examined by Mr. Fedden.

The principal object of Mr. Blanford's work in the field season 1881–82 was to endeavour to trace northward the well-marked series of tertiary rocks of Sind, and to follow their continuation if possible into the Punjab, where there is not the same clue to classification in the presence of marine beds above the eocene. Before taking up this work Mr. Blanford was called upon to report again upon the coal deposits to the west of Sibi, so he marched by the Bolan pass to Quetta, examining the coal seams of Mach on the road. From Quetta to Sibi he returned by the Harnai route, and visited the Sharag coal locality, after which he skirted the western boundary of the Bugti hills, and then marched from Jacobabad to Harrand in the Punjab, through the heart of the Bugti country. From Harrand he proceeded northward along the eastern flank of the Suliman

* "Records," Vol. XV., Part 3.

range to some distance north of Dera Ghazi Khan. Here a severe attack of fever compelled him to leave and return to England. Besides effecting some important alterations in Mr. Griesbach's work about Quetta, one of the results of Mr. Blanford's work was to show that post-eocene marine deposits of Sind do not continue north to the Punjab border. It was also found that the main chain of the Suliman is composed of hard whitish sandstones, apparently cretaceous, overlying limestones and limestone shales, with a few fossils belonging to the same system. By this important piece of reconnaissance the greater portion of the gap between Sind and the Punjab was bridged over. Throughout the area no beds of older age than cretaceous were observed; by far the greater portion being covered with tertiary deposits, the cretaceous rocks protruding only in the neighbourhood of Quetta to the westward and along the Suliman range to the eastward. The efforts made to trace a connexion between the tertiary deposits of Sind and those of the Punjab by following the rocks themselves to the northward, were fairly successful, and some interesting fossils, mammalian and molluscan, were obtained from Lower Siwalik beds, at localities discovered by Captain Vicary nearly 40 years previously in the Bugti hills.

On the termination of his short leave in England Mr. Griesbach obtained permission to visit some places on the Continent, the collections made in Armenia by Staatsrath von Abich proving especially interesting in their close relationship to some of the Himalayan fossils. On his return Mr. Griesbach proceeded to the Tibetan frontier, but the cold was so intense as to impede his explorations considerably. Mr. Oldham, who accompanied the Manipur-Burma Boundary Commission, made a complete traverse of the main range into the great alluvial and tertiary basin of the Chindwin river. He also marched from Manipur northward into the Naga hills, returning by the Assam valley, the indications proving that the range is altogether a secondary one, a mere fender of the great Malayan crystalline axis.

During the year two parts of Vol. XIX. of the "Memoirs" were published, the first being a description, with numerous illustrations, of the great Cachar earthquake of the 10th January 1869.

The circumstances of this earthquake were observed and noted by the late Dr. Oldham, superintendent of the survey, but the materials were not published till 1883, when they were collated and skilfully discussed by Mr. R. D. Oldham. The shock, it appears, originally

came on at Silchar at a quarter to 5 p.m., with a gently undulating movement, which, however, rapidly increased until neither men nor animals could keep their legs, but were thrown down; the water in tanks and rivers was violently agitated, and the Barak river rose in huge waves and wrecked numbers of boats. The landslips caused were numerous and extensive, and many homesteads were carried down into the stream. At Manipur the Political Agent found the motion of the ground most violent; it seemed to rise and fall in waves of about three feet in height, and the Raja's palace as well as other houses were ruined, and there was some loss of life. At another place (Kussilong), about 90 miles from Chittagong, a correspondent reported that "It burst with tremendous force. The "undulations were very severe and lasted nearly two minutes. "It seemed as if some mighty wave were sweeping on under the "earth, and as it passed the solid earth rose and fell with a motion "distinctly visible along the banks of the river and in the hills "beyond. The ground was seen to roll wave-like, the hills to reel, "and the trees to wave to and fro. The spectacle was wonderful "and fearful." The extreme limits of the area over which the same shock or group of shocks was experienced must have exceeded 650 miles from north-west to south-east, and 400 miles in the conjugate direction of north-east to south-west. Allowing for those districts from which no reports happened to be received, the area affected must have been fully a quarter of a million of square miles, a tolerable index to the vastness of the forces developed.

Mr. Oldham is of opinion that the shock originated in a fissure above 20 miles long, running underneath an area about three or four miles broad and from 20 to 30 miles long, situated in north latitude 26° and east longitude 92° 40′, on the northern borders of the Jamtia hills. The mean depth of the focus was probably about 30 miles, and the velocity of the wave particle 20 or 30 feet per second. The rate of transit could not be satisfactorily determined.*

The second part of Vol. XIX. of the "Memoirs" issued during the same year (1882) contained a list of the thermal springs of India, compiled by the late Dr. T. Oldham, and brought out by his son. The geographical position, latitude and longitude, elevation of the locality above sea-level, and the temperature of the water of the spring are all given. The list is far completer than the last one

* A catalogue of Indian earthquakes, from 833 A.D. up to 1869, was prepared by Dr. Oldham and published in the "Memoirs," Vol. XIX.

prepared by Mr. R. Schlagintweit,* containing as it does 301 names of springs as against only 90 enumerated by Mr. Schlagintweit.

Five fasciculi of the Palæontologia Indica were brought out in 1882, comprising a description of the fossil flora of the South Rewa basin by Dr. Feistmantel, the Siwalik and Narbada Equidæ, being Part 3, Vol. II., of the Tertiary Vertebrata Series, by Mr. Lydekker, a fasciculus on the Brachiopoda of the Salt range by Dr. Waagen, and two fasciculi on the fossil Echinoidea of Sind by Professor Martin Duncan and Mr. Percy Sladen.

During the year 1882 Mr. W. T. Blanford was obliged to take sick leave to Europe, and under medical advice he was subsequently compelled to retire from the service. He had spent 27 years in the arduous work of the Geological Survey, in which from the very outset he had taken a leading part. He wrote part of the report on the Talchir coal fields, the first paper in the "Memoirs," which have since extended to twenty-four volumes, containing numerous contributions from his pen. Besides his regular geological labours, Mr. Blanford has done a vast deal for the zoology of India, on which he is the highest authority. He was twice deputed on special missions out of India—with the army to Abyssinia, and with the Seistan Boundary Commissioners to Persia: and published special accounts of his researches in both those countries. He was twice (in 1878 and 1879) elected President of the Asiatic Society of Bengal, and so long ago as 1874 he was elected, at his first nomination, a Fellow of the Royal Society. In 1876 Dr. Oldham, on retirement, recommended Mr. Blanford as his successor as Superintendent of the Geological Survey of India; of this he was deprived only by a small matter of seniority, and in recognition of his high claims Government rewarded him with a special personal remuneration above the pay of his appointment. Personally, as well as professionally, Mr. Blanford's departure was much regretted by his colleagues and the Government.

Since Mr. Blanford's return to England, he has undertaken the editing of the "Fauna of British India," at the request of the Secretary of State, 5½ volumes of which have already appeared. It is designed to form a complete series of manuals of Indian zoology for schools and for students, and will be the standard work on the subject.

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* Journal of the Asiatic Society of Bengal, Vol. XXXIII., p. 49, 1864.

Of the work achieved during 1883 Mr. Griesbach's was probably the most interesting, dealing as it did with the main Himalayan range and its grand formations. He completed the survey of the Hundes basin to its western limit on the flanks of the gneissic mass of the Porgyal mountain which separates Hundes from Spiti. For some important horizons he satisfied himself of the identity of the sections in Spiti (as partly determined by Dr. Stoliczka) and those in Hundes. From this region Mr. Griesbach had to hurry late in October to join the expedition to the Takht-i-Suliman, on the North-West frontier.* This remarkable peak consists of the cretaceous sandstones with limestones described by Mr. Blanford as forming the crest of the range 80 miles to the south.†

In Jaunsar, in the Lower Himalayas, Mr. Oldham succeeded in introducing two unconformable and almost wholly detached groups above the Deoban limestone where a great gap had always existed between the tertiaries in the Simla section and the Krol group, for which no age later than the trias had been conjectured. Further researches into the character of the granitoid gneiss of the Himalayas were made by Colonel McMahon, leading to the conclusion that much of it is intrusive and must properly be called gneissose granite.

An important contribution to the literature of the year was Mr. Lydekker's volume on the north-west Himalayas ("Memoirs," Vol. XXII.), the researches in the field for which had been concluded two years previously.

Mr. La Touche was to have taken up the examination of the coal field in the Garo hills, his preliminary visit to which was described in the "Records," Vol. XVI., page 164, but instead he was deputed to accompany Colonel Woodthorpe's party in the exploration of the Dehing basin, a region of much interest, as it probably reaches beyond the zone of tertiary rocks fringing the Upper Assam valley and beyond the range of the Arakan-Manipur axis. Unfortunately this plan was interrupted by the Aka raid, the party being diverted into that territory and Mr. La Touche with it. The ground is Himalayan ground proper not far to the west of the Daphla district, visited by Colonel Godwin-Austen in 1865, and probably like it in structure.

The eastern parts of the Madura and Tinnevelli districts were examined by Mr. Foote, and a sketch of the geological features of

* *See* above, p. 147. † "Memoirs," Vol. XX., Part 2.

the region appears in the "Memoirs," Vol. XX., Part 1. The districts both form part of the tract lying between the water-parting along the axis of the Southern Ghâts and the Bay of Bengal. Along the sea-board there runs a belt of sedimentary rocks, and westward a great band of crystalline rocks, while the greater part of the low country occupied by gneissic rocks in South Madura and North Tinnevelly is covered with a widespread deposit of regur or black cotton soil. Along the coast from Cape Comorin to the Paumben channel a series of marine rocks, generally calcareous grits, forms a narrow and broken fringe. This formation was once widely extended, but has been removed by denudation, while the outliers and patches of beds which have been left testify to the fact that since their formation under the sea the country must have undergone an elevation of close upon 200 feet, if not more. There is evidence of a somewhat similar phenomenon in an upheaved coral reef on the northern coast of Rameswaram island, between India and Ceylon; and the same cause, in Mr. Foote's opinion, upraised both the island and the mainland. It is difficult to resist the inference that the same upheaval led to the formation of what is known to the Hindus as Rama's bridge, and to Mussulmans and Christians as Adam's bridge, the long narrow isthmus which once united Ceylon to India; while to the same action again may be attributed the formation of the long line of islets running parallel with the south coast of Madura. Local history claims that Rameswaram island was once completely joined to the terra firma on both sides, and that both the Paumben strait and the other passages to the eastward were breached by a tremendous storm about 1480 A.D. The action of the waves has broken the barrier into large flat blocks, which so strongly resemble a series of gigantic stepping stones that it is easy to fall in with the imagination of the author of the Ramayana, which ascribed artificial construction to the bridge.*

The two great groups into which the soils of Tinnevelly and Madura are divisible are the red and the black, the former being

* According to the famous old Hindu epic, the construction of the bridge was due to the industry of the great army of monkeys and bears led by Rama and his long-tailed friends, Sugriva and Hanuman, when they proceeded to invade Lanka (Ceylon), during the war with Rama, the king of demons and the abductor of Sita, Rama's wife. The engineering part of the undertaking was specially entrusted to the monkey Nala, a son of Viwakarma, the famous architect. Perhaps the upheaval of Rama's bridge may have occurred within the semi-mythical time preceding some invasion of the heretical Buddhist kingdom of Lanka (Ceylon) by the Brahmanical Aryans of the mainland and their Dravidian allies.

generally the product of decomposition *in situ* of underlying ferruginous rocks. A very curious feature connected with this red loamy soil is the enormous number of white-ants' nests, which are of a bright red colour, attain a height of five to eight feet, and are often so numerous as to affect very strikingly the character of the foreground. There is no part of the south of India in which blown sands play so large and important a part as in the Tinnevelly district and along the south coast of Madura. They are of two kinds—the red sand or *teris* and the white, which are ordinary sand dunes. The former are attributed by Mr. Foote to the action of the heavy and continuous gales prevalent (sometimes for four months) during the S.W. monsoon on the broad belt of deep red loam which skirts the eastern base of the Ghâts. It is evident that these sands bear a great resemblance, though on a smaller scale, to the red sands of the Nefûd or great desert of Central Arabia described by Mr. Palgrave, Lady Anne Blunt, M. Huber, and other Arabian travellers. But the origin of the red sands of the Nefûd is still involved in uncertainty.

Mr. Mallet's investigation of the iron ores in the Katni district, in north Jabalpur,* shewed that all the other conditions for extensive iron manufacture were favourable if suitable coal could be found. Mr. Fedden, by prolonging the season's work well into the hot weather, was enabled to complete his survey of Kathiawar. The area is principally occupied by Deccan trap, of which it was not desirable to attempt a detailed survey throughout, so the work lay principally in tertiary or post-tertiary deposits of the coastal region, with some secondary rocks on the north-east margin.

Five parts of the "Memoirs" were published during the year. Part 3 of Volume XIX. contained the catalogue of Indian earthquakes mentioned above (page 258, note), and Part 4 Mr. Oldham's account of his examination of an area of about 1,800 square miles to the east and in the north of the valley of Manipur, with the neighbouring Naga hills. This country is densely covered with vegetation, and for whole days one may march without seeing a single rock, while the want of population or else savages of doubtful temperament offered great impediments to Mr. Oldham's researches. Geologically, the region has no great feature of interest, and the economic minerals are poor.

* "Records," Vol. XV., Part 2.

The other volumes issued during the year (XX. and XXII.) contain the memoirs by Messrs. Blanford, Foote, and Lydekker, already referred to.

The Records for the year (Vol. XVI.) embrace 24 articles of varied interest with numerous maps and plates. Of the "Palæontologia Indica," a full part containing a large section of the Brachiopoda of the productus limestone of the Salt range, by Dr. Waagen, was published; also a part on the tertiary Echinoidea of Kach and Kathiawar, by Dr. Duncan. Mr. Mallet issued a descriptive catalogue of the systematic series of minerals in the museum, and a guide to the economic mineral products, giving a very instructive account of each class of substance, its use and distribution.

With the co-operation of Mr. H. F. Blanford, the Meteorological Reporter to the Government of India, some simple seismometric instruments were set up at Silchar, Sibsagar, and Shillong, forming a group for the determination of centres of earth disturbance in Assam.

During the year two able members of the Department retired. Mr. Wynne, who had left India on medical certificate in 1880, had, after several extensions of sick leave, to be finally invalided in 1883. He had joined the Indian Service in 1862, having already had several years' geological experience in Ireland. In India some choice fields of work fell to him, such as Cutch and the Salt range, excellent illustrated descriptions of which have appeared in the "Memoirs." Mr. Lydekker, the other retiring member, had had a short but a very busy career. He joined the Survey in 1874, and as soon as the collections were moved to the new museum and amalgamated with those of the Asiatic Society of Bengal, he undertook the arrangement and description of the extensive series of tertiary vertebrate fossils, large additions to which were made by Mr. Theobald in the Punjab. Mr. Lydekker's description of the Siwalik fauna in the "Palæontologia Indica" will form an enduring record of his zeal and ability.

During the same year two new assistants joined the Survey, Mr. E. J. Jones, A.S.R.M., and Mr. C. S. Middlemiss, B.A. (Cantab).

The Karnul cave explorations commenced by Mr. Foote, and continued by his son Lieut. H. B. Foote, R.A., proved to be on the whole encouraging, a large number of bones were secured, some of animals that do not now inhabit the region, some human remains and articles of human manufacture, the latter at the considerable

depth of 16 feet, but nothing to show that the caves had ever been used as dwellings or as a place of sepulture. Mr. Foote was also called upon to explore for coal along an intended line of railway between Haidarabad and the Kistna. Between Bezvada and the Singareni coal field, and from the latter to Haidarabad, the country proved to be all of gneissic rocks, but Mr. Foote's labours were rewarded by the discovery of a strong lode of rich iron close to the Singareni coal field.

Dr. King's survey of the coal fields on the north-east confines of Chattisgarh was described in the "Records" (Vol. XVII., Part 3). In South Rewa regular mining explorations of the Umaria coal field had been commenced under Mr. Hughes's direction in 1883, and the shafts proved so satisfactory that steps were taken to establish a colliery there with a branch railway from Katni to Jabalpur. Mr. Hughes also managed to complete the examination of the southern coal fields of the Rewa Gondwana basin, the total area of exposed measures proved to be no less than 1,800 square miles.

Mr. Bose took up new ground in the basin of the upper Mahanadi, but the results were not deemed satisfactory by Mr. Medlicott, who indeed referred prominently to this as an additional proof of the unsuitableness of natives of India for the faculty of independent research and critical observation required to make a good geologist. Mr. Medlicott adds that the Geological Survey is about the only branch of the public service in which natives could not as yet reasonably find employment.

Mr. Oldham submitted full progress reports of his work in the Himalayan region, embracing a section from the plains to the base of the main range; his detailed conclusions are summarised under nine different heads in Mr. Medlicott's report. Mr. Griesbach was, unfortunately, taken seriously ill at Kohat, after the expedition to Takht-i-Suliman, but after recovering his strength, at Simla he was appointed to accompany the Afghan Boundary Commission in the capacity of geologist. The results of the Takht-i-Suliman observations were published in the "Records" (Vol. XVII., Part 4), and the same volume contains Mr. Mallet's examination of ores from the Andaman islands.

Early in the season Mr. La Touche accompanied the expedition into the Aka hills, north of Tezpur, in Assam. The dense vegetation prevented any observation of the rocks except in the stream

courses. The section was found to correspond with that observed in the Daphla hills to the east by Colonel Godwin Austen, and with that described by Mr. Mallet in the Bhutan Duars to the west. Inside the tertiary zone there is a belt of carboniferous Damuda strata bordering the schistose rocks of the higher hills. Here too, as elsewhere, along the foot of the Himalayas, the coal is so crushed as to be unserviceable. Later on Mr. La Touche examined the Longrin coal field on the south-west edge of the Garo hills. His report, which is published with a map in Vol. XVII. of the "Records," Part 3, shows that the field offers an abundant supply of very fair coal easily accessible on the very borders of the plain of Sylhet.

In connexion with the record of Indian geological progress, mention may be here made of a very instructive discussion of geological homotaxis given by Mr. W. T. Blanford in his address as President to the Geological Section of the British Association on the occasion of their meeting at Montreal. Being mainly illustrated from Indian geology the paper was reprinted in the "Records." Mr. Blanford is inclined to modify Professor Huxley's statement that "for anything that geology or palæontology is able to show " to the contrary, a Devonian fauna and flora in the British Islands " may have been contemporaneous with Silurian life in North " America, and with a carboniferous fauna and flora in Africa."* Granting such conditions to be possible for a terrestrial fauna or flora, Mr. Blanford considers that the marine fauna would give a much nearer approximation to synchrony. Mr. Oldham also dealt with the same subject in the Journal of the Asiatic Society of Bengal for 1884 (Part II., p. 187), and illustrated from Indian palæontology the great discrepancies in correlations of time from fossil evidence. He also endeavoured to establish synchronous relations of distant formations through the evidence of periods of glaciation, and arrived at the conclusion that in early secondary times the crust of the earth did not occupy the same position with respect to the axis of rotation as it does now.

Two memoirs were published in 1884, Mr. Bose's on the Lower Narbada valley between Nimawar and Kawant, and Mr. Fedden's on Kathiawar, each with a map. They form Parts 1 and 2 of Vol. XXI. In the "Palæontologia Indica," five parts of Series X., the Indian Tertiary and Post Tertiary Vertebrata by Mr. Lydekker, were published during the year, forming a very valuable addition to

* Quart. Journ. Geol. Soc., Vol. XVIII., p. xlvi.

that branch of the Survey publications. Dr. Waagen also furnished two parts (Nos. 3 and 4) of the Brachiopoda of the Productus Limestone, and a huge fasciculus of Series XIV., with 18 admirably executed plates descriptive of the tertiary and upper cretaceous fossils of Sind, was issued from the pen of Professor Martin Duncan.

Some interesting contributions of ores, rocks, and other geological specimens were made to the museum from the International Exhibition held in Calcutta, the principal presentations being made by the Ministers for Mines in New South Wales and Victoria, and the Tasmanian Commissioners.

During 1885 Mr. R. D. Oldham took a trip to Australia to enable him to study the Gondwana rocks of that region, and his memorandum on the correlation of the Indian and Australian coal-bearing beds is published in Vol. XIX., Part 1, of the "Records." Dr. King was chiefly engaged in directing the practical exploration of the Rampur coal field, which is the southern portion of the Raigarh and Hingir basin, formerly surveyed by Mr. Ball in 1876, but unfortunately the coal has proved uniformly bad in quality.

During 1884–85 Mr. Foote was able to take up his survey in the Bellary district, from which he had been called away in the previous season to search for coal in the gneiss of Haidarabad. The Sandur hills to the west of Bellary were the principal objects of investigation; they are formed by one of the bands of transition rocks that traverse the peninsula with a N.N.W. trend, and are all remnants of a once widespread formation which Mr. Foote now unites and distinguishes as the Dharwar series, and shows to be unconformable to the gneiss with which it has been intimately associated by complete folding together. In the Sandur hills there occur masses of rich hæmatite. Mr. Foote made a careful examination of the well-known diamond field at Wadjra Karur, to which special interest attached on account of mining operations started there by Messrs. Orr and Sons of Madras. But in spite of the occurrence of a peculiar trappean rock, declared to be identical with the famous diamond matrix of Kimberley, no speck of the gem was discovered. Mr. Hacket covered a large area (some 3,000 square miles) of new ground in Mewar, in continuation of his previous work to the north. It is entirely composed of the same obscure rocks—the schist limestones and quartzites of the Arvali system in transitional relation with gneiss and granite masses. Mount Abu is a mass of coarse highly felspathic gneiss.

Mr. Griesbach contributed to the February number of the "Records" a small instalment of his observations with the Afghan Boundary Commission. The southern route taken to Herat crossed the continuation of the tertiary and cretaceous formation previously described by him at and west of Kandahar ("Memoirs," XVIII., 1), the hippuritic limestone being very prominent with copious intrusions of basic trap and syenitic granite. In the axial range of the Siah Koh and Doshakh, south of the Herat valley, palæozoic rocks make their first appearance, as represented by a carboniferous Productus limestone, dipping northwards towards the Hari Rud valley. The Paropamisus range, north of the valley, seems to be largely made up of a great plant-bearing series which Mr. Griesbach provisionally parallels with the Indian Gondwana system, conjecturing that it overlies the carboniferous productus-limestone. In notes of a year's later date, published in the "Records," Mr. Griesbach adheres to this general rock sequence, and describes its distribution in the Binalat and other ranges of eastern Khorasan.

The result of Mr. Oldham's observations in the Andamans is published, with a map, in the "Records," and gives generally the classification and distribution of the rocks, with a digest of all previous explorations. Mr. La Touche was again despatched from the Garo hills to take advantage of the topographical exploration party to the head waters of the Dehing* on the extreme east frontier of Assam. In that region the conditions are very unfavourable for geological observations on account of the dense vegetation. It has, however, been ascertained that the whole upper valley of the Dehing is occupied by tertiary deposits, chiefly sandstones, while the actual crest of the ridges to north and east are of crystalline rocks. Unfortunately, Mr. La Touche did not accompany the officers who crossed the water-shed, consequently the opportunity of extending the geological observations into the valley of the north-west branch of the Irawadi. A good season's work was done by Mr. Jones in mapping the whole area hitherto known as the Pench coal field, and for some distance to the west in the direction of the Shahpur coal field, on the south side of the Satpura Gondwana basin. The field is, however, remote and inaccessible. Further light was shed on the geology of the Lower Himalayan region, where the absence of fossil guidance has always proved a perplexity, by the discovery by

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* *See* p. 79.

Mr. Middlemiss of some fossils east of the Tal river. He ascribes the normal position of this Tal group as above the massive limestone and thus next below the nummulitic band. Mr. Middlemiss also investigated the circumstances of the Bengal earthquake, and secured some good observations in positions favourable for ascertaining the focus of the shock. The Kashmir earthquake, which was reported on by Mr. Jones, was far more difficult to investigate critically, owing to the rough mode of construction of the native houses, the heavy earthen roofs having simply collapsed between crumbling walls, leaving little trace of direction. The same cause also made it most disastrous in respect of loss of life.

Dr. Feistmantel, the permanent Palæontologist of the Survey, resigned his appointment at the termination of his two years' furlough, having accepted a professorship at Prague. In his three volumes on the Gondwana Flora this learned and energetic officer has cleared up many difficulties connected with the principal rock system of India, and supplied a standard for future work in that branch of palæontology.

The work of the Survey had necessarily suffered from the absence of a palæontologist, but, nevertheless, the co-operation of savants enabled some important papers to be issued during the year. The fossil Echinoidea from the Gaj or miocene series of Sind were described by Professor Martin Duncan and Mr. Percy Sladen, and two instalments of Dr. Waagen's work on the Salt range fossils were also published. Mr. Lydekker also brought out two parts of the "Palæontologia Indica," dealing with Indian Pretertiary Vertebrata, and a third part (No. 6 of Series X., on the Siwalik and Narbada Chelonia) devoted to tertiary and post-tertiary vertebrata.

During 1886 Mr. Foote, whose work had been confined to the Madras Presidency during the two previous seasons, mapped a considerable area, in extension of his previous work in Bellary, both of gneiss and of his Dharwar schistose series. The researches of Mr. Foote's son, Lieutenant H. Foote, R.A., in the Karnul cave resulted in the discovery of very interesting fauna, which has been described by Mr. Lydekker in the "Palæontologia Indica." A large number of the species, according to this authority, are now either totally extinct or not living in India, and are not newer than pleistocene. They display numerous affinities with African types, a feature previously noted regarding the tertiary Siwalik fauna

of India. Dr. King's regular work in the hills west of the Chattisgarh plains was necessarily interrupted by his having to superintend the coal explorations in the fields far to the east, which, however, did not promise a fair supply of fuel. In the remote hill country, far to the north of Korba, a large new coal field was traced out by Sub-assistant Hira Lal; it is the western extension of the measures noticed some years ago by Mr. Ball at their eastern extremity as the Lakanpur field. Mr. Hughes' deputation in charge of the Umaria colliery was followed by his examination of the rocks above the coal measures, in which he found some new localities for fossils. Mr. Jones's work during the season of 1886 was the completion of the survey of the southern coal field of the Satpura Gondwana basin. There are altogether 11 separate areas where the coal measures group is exposed, seven of them being in the Chindwara district, while four adjoining areas in the Betul district were mapped and described some years ago.* The quality of the coal, as ascertained from outcrop samples, was not very encouraging, and during the two seasons' work no recognisable fossils were found. Mr. Hacket's operations in Rajputana were confined to the older rocks, the Arvalis and the Vindhyans, to the west of which, in the more or less desert country of Jaisalmer, the existence of fossiliferous limestones has been known for many years. Mr. Oldham was deputed to explore in 1886 the northern extension of the jurassic strata towards Bikanir, for the purpose of seeing whether he could fix upon a Talchir bed, which all over India forms the base of the Gondwana coal measures. Mr. La Touche made good progress with his work in the Garo hills, and his notes appeared in the "Records" (Vol. XX.); and Mr. Middlemiss investigated an obscure point presented by the discovery of a long ellipse of crystalline schists surrounded by a narrow fringe of newer strata, immediately east of the Ganges and at the edge of the lower Himalayan region just inside the fringing zone of sub-Himalayan rocks.

On the 1st November Mr. Griesbach returned to India with the Afghan Boundary Commission not much the worse for his two years' wanderings. His notes appear in the "Records." The geology of the Herat valley is shortly described in Vol. XVIII., Part 1. Afghan and Persian field notes, dealing with Eastern Khorasan and the Herat province, are contained in Vol. XIX., Part 1, while a very

* "Records," G. S. I., VIII., 1875.

full and valuable sketch of the geology of Afghan Turkistan appears in Part 4 of the same volume. The fourth or concluding batch of notes treats of the return march of the Commission from Turkistan over the Hindu Kush and through Kabul to India.

In the little known region of Gilgit, Astor, and Baltistan, and the country beyond, the observations made by Dr. G. M. Giles, though not those of a professed geologist, supplied some valuable information about a large area from the Pamir through Wakhan and eastern Badakhshan across the Hindu Kush at its supposed roots, and back through Chitral and Yasin. The whole of the large area presented apparently an extension of the conditions known in Baltistan; no trace of a fossiliferous rock was seen; crystalline and schistose rocks greatly preponderated, with only a few less altered slaty specimens. Throughout the eastern and central part of the area an east-west strike was very constant, while on the west side, *i.e.*, on what is represented as the axis of the Hindu Kush, the prevailing strike of the rocks was north to south, though often irregular. There remains a belt of unknown ground (over 150 miles) between Charikar and Chitral to which peculiar interest attaches, both from a geological and geographical point of view.

Several parts of the "Palæontologia Indica" came to a natural close with the end of the year, Mr. Lydekker, who has earned much reputation in that branch, having pretty well cleared off all the fossil vertebrata, though of course further collections have since been made. With the fasciculus on the Echinoidea of the Makran series of the Baluchistan and Persian Gulf coasts Professor P. Martin Duncan completed a portly volume, forming Vol. I. of Series XIV., the "Tertiary and Upper Cretaceous Fauna of Western India." Dr. Waagen made good progress with his important volume on the fossils of the productus-limestone of the Salt range, one part (the Cœlenterata) being issued in 1886.

The year 1887 was marked by the retirement, on the 27th of April, of Mr. H. B. Medlicott, M.A., F.R.S., F.G.S., after a continuous service of over 30 years in India. Mr. Medlicott became Superintendent (a title afterwards altered to Director) after the retirement of the late Dr. T. Oldham in 1876, and the admirable and efficient manner in which he conducted the responsible duties of the Department is amply borne out by the official records of the Survey. In collaboration with Mr. W. T. Blanford, then Senior Deputy Superintendent, he produced the first and second parts of the

"Manual of the Geology of India," since out of print. Besides his part in the Manual, Mr. Medlicott wrote five of the memoirs of the Geological Survey of India, which are works on special formations or districts; but his peculiar genius for conducting the Survey and for treating the multifarious questions which came before him is more specially displayed in the "Records," to which he contributed no fewer than 44 papers in all.* His long and valuable services were thus acknowledged by the Government, on the receipt of his last annual report:—

"As this is the last occasion on which the annual report will be submitted by you, the Government of India desires to take the opportunity of placing on record its appreciation of your long and valuable services, and to recognise the zealous manner in which you have discharged the duties of superintendence and direction, and the devotedness with which you have supported the cause of Geological Science in India. I am to add that the marked advance which has been made in the investigation of the

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* The complete list of his non-official writings, as far as ascertainable, is as follows:—

"On the Geology of Portraine, county of Dublin."—Jour. Dub. Geol. Soc., V. 265, 1850–53.

"On the Sub-Himalayan rocks between the Ganges and the Jumna."—J. A. S. B., XXX., 22.

"Note relating to Siwalik Fauna."—J. A. S. B., XXXIV., pt. 2, 63.

"On the action of the Ganges."—P. A. S. B., 1868, 232.

"On a celt from the ossiferous 'Pliocene' deposits of the Narbada valley."—P. A. S. B., 1873, 138.

"Record of the Khairpur Meteorite of 23rd Sept. 1873."—J. A. S. B., XLIII., pt. 2, 33.

"Exhibition of a Meteorite from Raipur."—P. A. S. B., 1876, 115.

"Exhibition of Meteorites recently fallen in India, with remarks upon them."—P. A. S. B., 1876, 221.

"Remarks on Himalayan Glaciation." P. A. S. B., 1877, 3.

"Note on Mr. J. F. Campbell's remarks on Himalayan Glaciation."—J. A. S. B., XLVI., pt. 2, 11.

"Exhibition of the new Geological Map of India."—P. A. S. B., 1878, 124.

"Exhibition of some Geological specimens from Afghanistan."—P. A. S. B., 1880, 3.

"Exhibition of a specimen of rock-salt from the Chakmani Territory."—P. A. S. B., 1880, 123.

"Note on Chloromelanite."—P. A. S. B., 1883, 80.

"Note on the Reh efflorescence of North-Western India, and on the waters of some of the rivers and canals."

"Lithological Nomenclature."—Geol. Mag. IV., 83, 1867.

"The Alps and the Himalayas: a Geological comparison."—Quar. J. Geol. Soc., XXIII., 323, 1867; XXIV., 34, 1868; Phil. Mag., XXXIV., 396, 1867.

"On faults in Strata."—Geol. Mag. VI., 341, 1869, VII., 473, 1870.

Geological conditions of India during your tenure of office is most creditable to yourself, and that it is undoubtedly leading to the development of the mineral resources of the empire, as well as the material extension of scientific knowledge."

On Dr. King taking over the directorship in April 1887 from Mr. Medlicott, he found the staff of the Survey still below the normal number. The distribution over the vast area of the Indian Empire was as follows:—

Mr. Foote on special deputation to the Mysore Government.
Mr. Mallet, Museum and Laboratory.
Mr. Hughes, special deputation with the Deccan Company, Hyderabad.
Mr. Fedden, Vizagapatam.
Mr. Hacket, Rajputana.
Mr. Griesbach, just returned from the Afghan Boundary Commission.
Mr. Oldham, Salt range.
Mr. Bose, Chattisgarh.
Mr. La Touche, Assam.
Mr. Middlemiss, Himalayas.
Mr. Jones, Upper Burma.

Two of the vacancies were subsequently filled up by the appointment of Dr. Fritz Noetling (Berlin University) as Palæontologist, and of Mr. Philip Lake (Cantab.) as assistant superintendent; on the other hand, Mr. Hughes's engagement with the Deccan Company continued until May 1888, and Mr. Griesbach was deputed for two years to Afghanistan as geologist to the Amir of that country. Mr. La Touche was also selected for work under the Kashmir Government. These various calls from Native administrations were of course in the nature of distinction; nevertheless, they formed an interruption to the regular work of the Survey. Mr. Foote's study of the auriferous veins of Mysore resulted in a lengthy and valuable report, founded on a rapid tour through the province. Mr. Fedden, who was transferred to the Madras Presidency at the end of 1886, took up work in the Vizagapatam district, with the endeavour to fill in the large unsurveyed gap between the Godavari and the Ganjam districts in the Northern Circar, and he had been going on steadily with his work when he suddenly died at Vizagapatam on the 27th December 1887. He was one of the oldest and most valued members of the Department, and had only just attained the long looked-for promotion to the 1st grade.

Dr. King's executive work closed with his boring experiences in the Chattisgarh coal fields, one tract in which, near Korba, yielded workable coal of good quality. The credit of the find was due to Sub-assistant Hira Lal. Mr. Hacket continued his researches in Rajputana, and Mr. Middlemiss steadily and energetically pursued his proper work in the lower Himalayas about British Garhwal and Kumaun, the results of which are given in a series of papers in the "Records."

On the application of the Kashmir Government for a geologist to report on the sapphires in Zanskar, Mr. La Touche was detached from his recess work in Assam. He was able to work for a month at the spot which lies just below the snow line, and took the advantage to examine the Jammu coal, originally discovered by Mr. Medlicott, on which he was inclined to look hopefully. Mr. E. J. Jones was fully occupied until the end of the season in examining the principal coal fields in Upper Burma as well as the metalliferous mines in the Shan hills, reports on which appeared in the "Records." Another work by Mr. Jones claiming notice was the 24th volume of the memoirs "Southern Coal Fields of the Satpura Gondwana basin." Mr. R. Lydekker's description of the "Eocene Chelonia from the "Salt range"* was issued during the year, as well as Mr. Mallet's Part IV., "Mineralogy," of the "Manual of the Geology of India," a very fitting complement of that important and useful work.

The Madras gold-bearing rocks occupied Mr. Foote during the whole of 1888, and his observations thereon were published in the "Records" with a map showing the localities of gold occurrence in the presidency. The area over which these bands of transition rocks occur in Southern India is enormous, extending N.N.W. and S.S.E. over 192 miles, while the number of spots in this huge tract which have been mined in past times by a so far unknown people is very remarkable. The story of the struggles and ultimate success of the Kolar mines, which occur in the easternmost part of the Dharwar rocks, is well known, and Dr. King favours the conclusion that other gold fields of equal, if not superior, richness to these are still lying fallow. The Singareni coal field was successfully exploited by Mr. Hughes; the area proved greater than that of the Umaria estate and the Karharbari field; the coal was good steam coal with little

* In Series X., Vol. IV., Part III., of the "Palæontologia Indica."

or no clinker, and containing only the average amount of ash, while the entire series of the measures is within the easy reach of the surface.

Mr. Lake was deputed to work out the geology of the west coast in the long strip of country between Cochin and Karwar. One noteworthy discovery made was that of an oil shale among the strata underlying Calicut, indicating a possible relation with the oil traced in the Alleppi mud bank and the smooth waters adjacent. Mr. Bose was commissioned to make a thorough examination of the Gosalpur manganese ores in the Central Provinces. He estimated the total quantity of pyrolusite (manganese ores) at about 50,000 tons in addition to about 20,000 tons from neighbouring deposits, a supply which may be described as practically inexhaustible. Mr. Bose subsequently resumed work in Balaghat among the transition and Vindhyan rocks, while Babu Kishen Singh investigated the limits of the Deccan trap in the Chindwara district, after which he joined Mr. Bose in the study of the more intricate but economically important rocks of Balaghat. Mr. Hacket was unfortunately unable to extend his observations sufficiently to the westward of Jodhpur to touch on the Gondwanas. His work lay west of Mount Abu and the Arvalis, but partly from the increasingly complicated association of the very altered rocks in that region, and partly from failing health which necessitated his retirement from the service, but little progress was made towards a solution of the geology of the region. Mr. Oldham procured specimens of flexible sandstone, a very peculiar decomposition-form of certain quartzites belonging to the transition series occurring at Kaliana in the Jhind State, for which frequent inquiry had been made both from Europe and America.

Renewed search for materials required for the development of the iron industry at the Barakar (Bengal) works was prosecuted by Mr. Jones, and further progress was made by Babu Hira Lal in mapping the extensive coal tracts of the western portion of Chota Nagpur. Portions of the Rampur, Sirgujah, and Lakhanpur coal fields and of the adjacent area were described; all the coal outcrops were examined and recorded, and assays were made of such seams as were thought worth trying, some of them giving very fair results. Attempts were also made to test the capabilities of two of the coal fields of the Rajmahal hills, but the results were not thoroughly conclusive. On this point Dr. King remarks that skilled and experienced miners are rare in India, while boring plant

is almost equally difficult to obtain. The best plan for coping with these difficulties, he suggests, is to vest the conduct of these operations in the hands of the Geological Survey, who would arrange for sets of boring and mining plant to be stored at a convenient centre, the actual duties being entrusted to a mining manager with a small staff of subordinates, selected in some cases from young men trained in an engineering school like Sibpur College. By this means mining questions would be settled more quickly and economically, and a class of trained reliable men would be gradually formed in India ready to fill the many posts now filled by highly paid men imported from England or the Continent.

Dr. King paid a visit to Baluchistan and the Sind frontier to inspect the coal outcrops and oil resources in those parts. At Khost on the Sind-Pishin Railway thin seams of tertiary coal were being worked at the outcrops a mile or so behind the station, but in face of the very fitful continuity of the coal and the extremely unstable character of the beds above and below, necessitating a costly mode of holding up the workings, Dr. King recommended a close stratigraphical survey of the valley before further extension of the operations. As to petroleum, that brought to the surface by Mr. R. A. Townsend at Khatan gave good promise, and Dr. King says there are other likely localities among certain bands of the tertiary rocks.

During the year Mr. La Touche's deputation with the Kashmir Durbar came to a close; he had not only given valuable information regarding the sapphire rocks in the Zanskar district, but also on the Jammu coal and the ironworks and ores near the village of Soap in the Kashmir valley. On his return through Murree he also furnished a report on the water supply of the station.

Owing to the demand for latest information respecting the geological structure of the Himalayas, and to the fact that there had been no general review of our knowledge thereof since the publication of the "Manual," Mr. Oldham put forward a valuable paper in the "Records" on the sequence and correlation of the pre-tertiary sedimentary formation of the Simla region of the Lower Himalayas. A later paper of his on the geology of the North-Western Himalayas gives further observations in Spiti, Ladak, and Kashmir. Mr. Middlemiss also contributed a further paper (No. III.) on the study of the crystalline and metamorphic rocks of the Lower Himalayas, Garhwal, and Kumaun.

Mr. R. A. Townsend, superintendent of petroleum works in Baluchistan, was deputed during the rains to look up the oil indications in the neighbourhood of the Naga hills, the geological relations of which had already been dealt with in the papers of Messrs. Medlicott and Mallet. Mr. Townsend's report on Makum was very encouraging. The oil fields of Yenang-gyung, Thayetmyo, and other places in Burma were examined by Dr. Noetling, though this involved of course the temporary stoppage of his proper work as palæontologist of the Survey. He also recognised silurian rocks in the Shan hills, with the limestones of which is associated a very important and extensive band of iron ore, and his expedition to the ruby limestone tracts of Madya and Kya-whyat yielded some satisfactory information. Mr. Hughes on rejoining the Survey was also posted to Burma. In connexion with his researches there he made a special visit to the mines of Perak, after which he investigated the tin ores of Tenasserim.

The publications of the year comprised 16 papers (five of which were of considerable economic interest) in the "Records," a very useful bibliography of Indian geology compiled by Mr. Oldham, and the concluding part of the "Productus Limestone Fossils of the Salt Range," by Dr. Waagen.

At the International Geological Congress held in London in September 1888, the Indian Survey was represented by Mr. Medlicott and Mr. W. T. Blanford, while Mr. Oldham also availed himself of a brief term of privilege leave to exhibit there specimens of interest from India. Mr. Blanford had also been officially deputed by the Government of India to represent the Indian Survey at the Congress in Bologna in 1881 (*see* page 255), and at Berlin in 1885.

In 1889 Mr. Foote examined the auriferous tract around Chiggateri, and considered it well worthy of being systematically prospected. He also investigated the economic geology of the Sandur State, where are great beds of hæmatitic iron ore, affording a practically inexhaustible supply of iron. The only difficulty in the way appears to be the scarcity of fuel in the immediate neighbourhood. On the southward slope of the western range of the Sandur hills, Mr. Foote discovered an important argillite formation very rich in nodular oxide of manganese or pyrolusite, capable of being easily mined by open workings on a large scale. Mr. Lake surveyed a considerable tract extending over some 1,000 square miles in South Malabar, but was unable to complete the blank still existing here in the geological map, as he was then transferred to

Baluchistan to explore for coal and oil. At the close of the working season, and just as the S.W. monsoon was bursting on the coast, Mr. Lake was deputed to Alleppi to study the action of the famous mud banks there.*

The question of utilising the clays and coals occurring in the neighbourhood of Jabalpur for pottery works has claimed attention for years past, and Mr. Mallet made an exhaustive examination which led to the satisfactory result of works being started at Jabalpur by Messrs. Burn and Co. of Calcutta.† Mr. Mallet also made an interesting series of experiments on steatite from various parts of India. This was in response to a demand preferred by the Secretary of State, and the tests applied proved that the product of the Karnul district of Madras was the most likely to compete successfully with the costly material now imported from Germany. Dr. King considers that if steps were taken to work quarries the prospect of this new industry would be very hopeful.

The development of the gold industry in Madras has led to attention being turned to Chota Nagpur, which from time immemorial has been known for its native gold washings and occasional finds of decided fragments of gold, and a syndicate has been formed to work the neighbourhood of Sonapet. Geological reports on the subject already exist from the pen of Mr. V. Ball, but Dr. Noetling has submitted a report‡ containing some further information.

In Extra-peninsular India Mr. E. J. Jones took up a further examination of the outcrops of coal in the Sharigh valley, and came to the conclusion that the Khost seam is still the one which can be relied upon for fuel for that section of the frontier railway. Mr. R. D. Oldham has been investigating the coal and oil condition of the tract traversed by the railway, a task which has for the present delayed the publication of his work in the Dehra and Simla portion of the Lower Himalayas. Mr. La Touche was engaged on more detailed reports on the coal fields of the Khasia and Jaintia hills, and at the conclusion of the working season he was attached to the Lushai column of the Chin-Lushai expedition, which investigated the wild and obscure intermediate country between Chittagong and Upper Burma.

* A full account of these banks and of the literature of the subject has been written by Dr. King, and will be found in the "Records of the Geological Survey of India," Vol. XVII., pp. 14-27.

† Mr. Mallet's report appeared in the "Records" for May 1889.

‡ *See* "Records" for 1890, Part II.

The investigation and working of tin in Tenasserim continued in the hands of Mr. Hughes, and towards the end of the year a professional staff of Europeans and Chinese miners were obtained from the Straits Settlements. The conditions of tin mining in the Mergui district are fully set forth in Mr. Hughes's paper in the "Records" for August 1889.

In Upper Burma much was done by Dr. Noetling in the rather rapid explorations which he had to make in regions known for coal, oil, iron, and precious stones; while so engaged he was also employed in framing suggestions for the Government for a code of mineral concessions and leases. His most important works were reports on the Yenan-gyung oil fields and Chindwin coal field.

In July 1889 Mr. Griesbach returned to India after his tour of deputation to the Amir of Afghanistan. During his journey in the previous year up the Logar valley to the Khurd Kabul valley, Upper Wardak, Cherkh, Kharwar, Zanakhan, Ghazni, &c., the most interesting geological work was the recognition of at least three horizons, the rhætic with lithodendron (in Kharwar), the upper jurassic (or possibly neocomian) plant beds near the Shutargardan, and finally, well-developed nummulitics in Kharwar and Shilghar. He examined the copper lodes of the Logar and Khurd Kabul areas, the magnesite of the Logar and entrance to the Tangi Wardak, the graphite of Cherkh, the iron and lead ores of Kharwar, and the argentiferous lead ore of Zanakhan near Ghazni. It turns out also that the entire Surkhab valley from near Doab-i-Mekhyari to near Dahana Iskar is practically one big coal field with numerous thick seams of good coal of triassic and rhætic age.

Dr. Waagen's further contribution on the Salt range fossils in Part I., Vol. IV. (Geological Results), was issued at the close of the year. Several important modifications in the classifications originally adopted have become necessary, owing to very interesting discussions of fossils by Dr. Warth, the last and most remarkable of these discoveries, that of trilobites, having been announced by Dr. King, in the Records for 1889, p. 153.

During 1890 Mr. Foote, the only officer of the Survey left to carry on the work in Southern India, completed the examination of the southern half of the Bellary district, in quest of the auriferous condition of the Dharwar series. The auriferous indications were, however, not worthy of particular notice, though considerable additions were made to the existing knowledge of the occurrences

of iron ore in the Dharwars. During the construction of the Bengal-Nagpur Railway, a seam of coal was struck in the foundation of a bridge on the Ib river, in the Central Provinces; but the coal proved to be not of much better quality than that already known in the field, though its uniformity and thickness were all in its favour. In the Bengal Presidency the Daltonganj coal field became the scene of fresh boring operations, while Mr. Bose explored the coal area south of Kalimpong, in the Darjeeling district. As a rule, the coal is very high dipping and much crushed, while faults are numerous; thus the working of it will be very difficult and precarious. The quality of the coal is, however, good, and a great part of it can be coked. In Baluchistan, Mr. Oldham added very considerably to our knowledge of the coal, oil, and water resources in British Baluchistan, and a special report on the more favourable sites for petroleum explorations in the Harnai district was published in the May number of the Records. A hopeful specimen of mineral oil was obtained from the Sherani country, and Mr. Oldham was enabled to visit the spot during the late Zhob Valley expedition in November last. The oil is clear, limpid, of a pale yellow colour, and issues from a band of hard unfossiliferous sandstone, near Mogulkot, perfectly free from water. Mr. Oldham's general conclusions are that there can be no doubt of the existence of oil of excellent quality and great value in the district, but that it would be premature to undertake any expensive operations at present. Exploration for coal in the Baluchistan region has been prosecuted in the Bolan valley and in the hills east and south-east of Quetta. The best coal, as regards both quantity and quality, is found in the Zarakhu valley.

The elucidation of certain obscure points in the geological history and structure of the Salt range was left to Mr. Middlemiss, who was seconded by Mr. Datta; the former also examined the coal tract in the Hazara country. Tin exploitation is still being carried on in Tenasserim under Mr. Hughes, but under considerable disadvantages in the way of climate and insufficient means of communication. Dr. Noetling has been engaged in directing the demarcation of the oil-bearing tracts in the Magive, Mingyan, and Pakoku districts, and in surveying the coal fields, ruby, and tourmaline mines in the Shan States.

As may be inferred from the foregoing, the larger and more important results in 1890 were in economic research. Still geological

investigation has not been allowed to stand still, and some advance has been made in Baluchistan, the Punjab, and Burma, by Mr. Oldham, Mr. Middlemiss, and Dr. Noetling. A discovery of fossils in a series of limestones on the outskirts of the Shan plateau, east of Mandalay, which he had already noticed as bearing a very strong resemblance to certain limestones of the lower Silurian system of Sweden and Western Russia is pronounced by Dr. King to be of the grearest geological interest and importance as indicating that a branch or arm of the Arctic portion of the ocean by which the lower Silurian beds were deposited, reached at least to 22° N. lat. of the Indo-Chinese peninsula; it is even likely that it extended still further to the south, as the limestone beds of the Shan hills are again met in Tenasserim.

Mr. Griesbach was engaged until October 1890 on his Memoir on the Geology of the Central Himalayas, which will be issued very shortly; and has since been attached in the capacity of geologist to the Miranzai Expedition.

During the same year (1890) the usual volume of the "Records," consisting of 23 papers, has been issued; of these, 12 bear on industrial or economic subjects. Vol. XXIII. also contains the second part (Madras and the North-West Provinces) of the Provisional Index of the local distribution of important minerals, miscellaneous minerals, gem stones, and quarry stones in the Indian Empire, which has been much sought after.

One memoir was published, forming Part 2 of Volume XXIV. In this, Mr. Middlemiss has contributed much new research to the physical geology of the Sub-Himalaya of Garhwal and Kumaun. The remarkable speculation arising out of a sudden development of interest in the auriferous conditions of the Chota Nagpur Province has created a great demand for those publications of the survey which contain even a slight reference to the geology of that region, and as a consequence, Vol. XVIII., Part 2, of the Memoirs, and several parts of the volumes of the records are now out of print.

A complete and detailed index to all the papers published in the first 20 volumes of the Records has been prepared during the past year, and issued quite recently. This publication will prove of the greatest use to those desiring to consult the detailed papers on Indian geological topics. A "Bibliography of Indian Geology," or list of books published up to the end of 1887, has also been published by Mr. R. D. Oldham.

The tracts throughout the Indian Empire still awaiting geological examination are of very large extent. In India proper, south of the Himalayas, an area of about one-fourth is represented on the latest "state of progress" map of the Geological Survey as having been "mapped, reported on, and published." It is true that throughout a considerable area thus represented, the topographical maps used as a basis for geological surveying were very imperfect, and consequently a more detailed survey may hereafter be necessary. But, on the other hand, most of the tracts, such as coal fields, demanding close mapping, have been completed, and an enormous area is occupied by the alluvial deposits of the Indo-Gangetic plain and by the Deccan trap, neither of which, so far as is known at present, requires to be surveyed in detail. The remainder of the unsurveyed area is occupied to a great extent by gneissose rocks, the examination of which has been postponed partly because of the rarity amongst them of useful minerals, partly because of the great difficulties presented by them.

It is very difficult to form a trustworthy comparative estimate of the work that remains to be done before the geological mapping of the Indian Peninsula can be regarded as fairly complete, but probably about half the work of actual mapping remains to be done.

In the Punjab, Kashmir, and Sind, the progress has been greater, though much of the work (as has been shown in the case of the Salt range) will need revision. Baluchistan is almost untouched. The North-western Himalayas cannot be regarded as nearly half finished, and of course the range east of Garhwál is, with the exception of a few sections, chiefly in the lower ranges, geologically unknown. Of the countries east of the Bay of Bengal, some portions of the Assam hills and the province of Pegu, with the southern part of Arakan, have been surveyed, all the remainder of Burma, including besides Upper Burma, Martaban, and Tenasserim, together with the enormous tract of country between Burma, the Assam valley, and Eastern Bengal, is unsurveyed.

Roughly, it may be said that west of the meridian of Calcutta, the mapping is half finished or nearly so; east of the meridian of Calcutta only a very small proportion of the area, certainly not more than one-sixth, has been geologically surveyed. A large amount of exploration and of reporting upon useful minerals has

been carried out, but much of this reporting, which delays the regular work of the survey, and at present appears to have completely stopped it, is necessary because the survey has not been extended to the areas on which reports are required.*

There is still great uncertainty as to the total annual yield or out-turn of the different kinds of minerals in India. With a view to the improvement of our existing knowledge, a valuable index of the local distribution of important minerals, miscellaneous minerals, gem stones, and quarry stones in India, has been prepared by Dr. King. The primary object of the list was to help the local authorities in drawing up the returns for an annual statement, showing the quantities and value of mineral products in British India, which should be published in the "Mining and Mineral Statistics of the United Kingdom" of Great Britain and Ireland. The products themselves are grouped by Dr. King under the following headings: *Important Minerals,* including coal, iron ores, gold, petroleum, and salt; *Miscellaneous Minerals,* including alum, antimony ores, arsenical minerals, asbestos, bismuth and cobalt ores, borax, chrome ores, copper ores, corundum, gypsum, lead ores, magnesia minerals, manganese ores, mica natron, nitre, ochres, phosphates, platinum, plumbago, soapstone, soda, salts, sulphur, tin ores, zinc ores; *Gem Stones,* including amber, beryl, diamond, garnet, jade and jadeite quartz, &c., rubellite, ruby, sapphire, spinel, and *Quarry Stones,* including clays, granite (gneiss, &c.), laterite, limestone (marbles, kunkar, &c.), slate, and trap.

* I am indebted to Mr. H. B. Medlicott and Mr. W. T. Blanford, the two greatest authorities in this country on the subject of Indian geology, for the above statement respecting the geological work that still remains to be done.

XIII.

INDIAN METEOROLOGY.

The Indian Meteorological Department was officially established by the Order of the Government of India, in the Department of Revenue, Agriculture, and Commerce, No. 56 of the 27th September 1875. A few months before that, Mr. H. F. Blanford, F.R.S., the Reporter and head of the Department, had made a tour through Berar, the Central and the North-West Provinces, Oudh, the Punjab, Bengal, and subsequently the Madras Presidency and the Nizam's dominions, visiting the principal observatories, and taking steps to supply stations with instruments in which they were deficient, to get all the barometers satisfactorily compared, and to obtain trustworthy determinations of the elevations of the instruments above sea-level.

At the time of the establishment of the Department there were 84 observatories in India and its dependencies (exclusive of Ceylon). Two of these (a private observatory at Vizagapatam, and one established by the Portuguese Government at Goa) were independent of the British Government; eight were under special superintendents, or attached to special Government departments, and 74 were administered by local meteorological reporters or by the provincial sanitary commissioners. The observatories were very unequally distributed, being somewhat overcrowded in the alluvial Sub-Himalayan plain, and unduly sparse over the whole of Western India and some parts of the peninsula. But much valuable information on the meteorology of the country might, nevertheless, have been gathered from them, had the resulting data been comparable and accessible to persons in other presidencies.

Neither of these conditions were fulfilled, however, except partially and very imperfectly, and up to 1876 it had been impossible to collect and utilise the registers for discussing the meteorology of India as a whole.

The reorganisation of the department, which was sanctioned on the lines suggested by Mr. Blanford, involved:—

1. A redistribution of the observatories, and the provision of suitable additional stations. Except under some special conditions, it was proposed to arrange as uniform a distribution of the observations as the circumstances of the country would admit of.

2. The rendering the data from all observatories comparable *inter se* and also with those of known standards. To accomplish this, a rigorous comparison of the instruments was requisite, uniformity in the mode of their exposure and methods of reduction, and a knowledge of the surroundings of each station.

3. The establishment of one or two observatories of a higher class in the interior as well as on the coasts of India, to furnish detailed and continuous registers, and also serve as depôts for verifying instruments, training observers for the minor stations, &c.

4. To more effectually supervise the work of all observatories, by relieving the local reporters of a large part of their former duties, which were henceforth to be undertaken by the General Department. Also to provide an additional local reporter for Western India.

5. To bring together the materials furnished by the observatories in all parts of India, and, as far as possible, from adjacent regions, for the purpose of discussion and publication, and this with the least possible delay.

The number of observatories was to be raised to 95, eight of the former observatories being abolished and 22 new stations being established.

The whole were divided into three classes, as follows:—

I. Three first-class observatories, at Calcutta, Allahabad, and Lahore, in addition to the Madras and Colaba observatories, which were to remain under the independent management of their own superintendents. These new observatories were to be furnished with self-recording instruments; that of Calcutta with barograph, thermograph, &c., similar to those of the Kew observatory, and those of Allahabad and Lahore with the meteorograph of M. Van Rysselberghe. These observatories were to be under the immediate charge of the reporters.

II. Twenty-one second-class observatories, at which (with two exceptions, viz., False Point and Saugor Island) observations were to

be recorded hourly, from midnight to midnight, on four days in each month, and at 10 a.m. and 4 p.m. on all other days. The chief object of this arrangement was to ascertain the diurnal variation of the chief elements and to furnish the means of correcting registers to true daily mean values. These stations were also to be furnished with self-recording anemometers. They were as follows:—

2 in Assam - -	- Sibsagar and Goalpara.
6 in Bengal - -	- Patna, Hazaribagh, Cuttack, False Point, Saugor Island, and Chittagong.
2 in North-West Provinces	- Agra and Rurki.
1 in Oudh - -	- Lucknow.
3 in Central Provinces	- Nagpur, Jabalpur, and Pachmarhi.
4 in Bombay - -	- Belgaum, Poona, Disa, and Karachi.
2 in Madras - -	- Bellary and Trichinopoly.
1 in Burma - -	- Rangoon.

At False Point and Saugor Island stations, which were established chiefly for warnings of storms, the orginal plan of six-hourly observations at 4 and 10 a.m. and p.m. was retained.

III. Seventy-one third-class observatories, at which two sets of observations of the principal instruments were to be recorded daily, at 10 a.m. and 4 p.m.

The publications of the Meteorological Department were to consist of an annual report on the meteorology of India for each calendar year, giving the abstract of the registers of all stations, together with a discussion of the meteorological features of the year, illustrated by charts of temperature, pressure, and wind directions, and also the original observations (corrected and reduced) of some of the more important stations. The other departmental serial was to be termed "Indian Meteorological Memoirs," and to include such of the work of the officers of the department as did not properly come within the scope of the annual report.

The library of the Bengal Meteorological Office was transferred to the general office, and was thus rendered available for both departments. It has since been greatly enlarged by purchases and presentations of works.

During the following year (1876–77) 11 new stations were founded, and an important improvement was effected in the work

of the older observatories, by the verification of all the thermometers and the withdrawal of all inferior instruments. A first instalment of the tabulated observations in Indian seas, extracted from the meteorological log-books in the Marine Department of the British Meteorological Office, was received during the same year, and proved to be of such extent and value that Mr. Blanford strongly recommended the speedy completion of the work.

Progress was also made in the collation of the registers of rainfall in former years. Unfortunately, the records for Northern India, ranging from 1851 to 1860, had been made over to the Messrs. Von Schlagintweit, to aid them in the preparation of their work on magnetic and meteorological observations in India, and although application was made to Mr. Hermann Von Schlagintweit-Sakülunski for the return of the original registers, that gentleman practically declined to let them go, except on conditions which were held to be unreasonable. Eventually, however, on Mr. Blanford's proceeding on furlough to Europe, he availed himself of the opportunity to visit Munich and obtain copies of the registers in question.

The meteorology of 1876 possessed a sinister interest in that in the two southern presidencies the failure of the annual rains was followed by wide-spread suffering and a heavy mortality, while Bengal was visited by a terrible storm flood of almost unprecedented destructiveness. With respect to the rainfall, it is certain that from an early period of 1876 the distribution of pressure in the Punjab and the Indus valley must have weakened, and perhaps diverted, the summer monsoon that reaches India from the Arabian Sea, and have given prevalence to the dry westerly winds that, as a normal feature of the hot season, blow from Baluchistan across a considerable part of the Bombay Presidency. Other causes also were probably at work, but the mere fact that a great disturbance in the normal distribution of the rainfall is found to accompany an abnormal distribution of pressure, which distribution was manifested some months in anticipation of the rainy season, is of considerable importance.

A manual of instruction for the guidance of meteorological observers was completed and issued during the year, together with the tables of reduction specially drawn up for use in India. To supplement this and encourage inquiry, a sketch of the meteorology of India, accompanied by an introductory chapter on the physical laws of the atmosphere and an outline of the physical geography of India, was prepared by Mr. Blanford, the whole forming an octavo

volume of about 300 pages, and published under the title of the "Indian Meteorologist's Vade Mecum."

Besides the Report on the Meteorology of India in 1875, the publications issued during the year were—

Part I. of the Indian Meteorological Memoirs, containing three papers, viz.:—

(*a.*) On the winds of Calcutta;

(*b.*) On the climate and meteorology of Kashghar and Yarkand;

(*c.*) On the diurnal variation of barometric pressure at Simla.

Part I. of the Indian Meteorologist's Vade Mecum.

The Meteorological Office for Bengal also published Mr. J. Eliot's report on the Vizagapatam and Bakarganj cyclones of October 1876. In this report, Mr. Eliot gave a very full discussion of the formation and progress of these two storms, based on data collected partly from ships which encountered the storm and partly from the registers of the coast observatories. He also gave an account of the disastrous flood which submerged the low alluvial tracts at the mouth of the Meghna. But perhaps the most valuable part of the report was that which dealt with the formation of cyclones. Previous theories had laid it down that cyclones originated from the action of two opposing winds, which resulted in a rotatory action. But as the winds preceding the formation of a cyclone are generally very light, this was practically a mechanical impossibility. Mr. Eliot's theory, on the other hand, ascribes the formation to the continued precipitation of rain raising the temperature of the cloud-forming strata by the emission of the latent heat of the condensed vapour and lowering the atmospheric pressure.

Mr. N. R. Pogson published a tabular statement during the year of the rainfall registered at the Madras Observatory in every month during the previous 62 years. The data in this table were discussed by Mr. W. W. Hunter, with special reference to the supposed periodicity of droughts and famines in Southern India, in a pamphlet which obtained a large circulation and attracted very general interest. Mr. Blanford, however, after investigating the question with a wider field of materials, was compelled to conclude that Mr. Hunter's results required some limitation.

The following year (1877–78) was marked by an important addition to the work of the Department, *i.e.*, the transmission by post daily of the 10 a.m. readings from nearly all the observing

stations. As, however, several of the distant observatories communicated very slowly with Calcutta, the charts compiled from these giving the isobars, isotherms, wind direction, and rainfall were necessarily often a fortnight in arrear. But as a step towards the transmission of weather reports daily by telegraph, and the eventual publication of weather probabilities, the new departure was important. It also enabled the reporter to exercise a continuous and most useful supervision over the daily work of each observer.

Altogether, on the 31st March 1878, there were 103 observatories at work in India and its dependencies (excluding Ceylon), and one in the Persian Gulf. All, except the private observatories, were furnished with barometers and thermometers, carefully verified and adjusted to those of the well-known standards in India or in Europe, and the elevations of by far the greater number of the barometers had been ascertained with great accuracy, while the preparation by the central office of the daily charts from the postal returns was already beginning to throw light on the connexion between the seasonal and daily atmospheric changes over the whole of India.

Besides the General Report on the Meteorology of India for 1876, and Part II. of the Indian Meteorologist's Vade Mecum, Part II. of the Indian Meteorological Memoirs was issued, containing the following papers:—

1. Storms in Bengal in 1876, with increased atmospheric pressure. By J. Eliot, M.A.
2. On the rainfall of Benares in relation to the prevailing winds. By S. A. Hill, B.Sc.
3. On the diurnal variation of the barometer at Calcutta and Hazaribagh. By H. F. Blanford.

Mr. Blanford also drew up from all the accessible records a catalogue of the cyclones of the Bay of Bengal. This was communicated to the Journal of the Asiatic Society of Bengal.

A system of issuing daily reports of the weather in all parts of India was set on foot experimentally by Mr. Eliot on the 15th June 1878, the observations recorded at 10 a.m. being telegraphed to Simla. To facilitate the transmission of these reports, a special telegraphic code was devised by Mr. Eliot and Mr. Pedler, which gave the whole of the requisite information in six words.

This system was found so satisfactory that it was determined to extend it to all observatories having telegraphic communication,

and furthermore to supplement it by an extended system of report of the rainfall from stations other than those provided with meteorological observatories. Arrangements were also made for transferring to the Meteorological Department the duty of working the time-ball on the semaphore tower of Fort William, which had been previously performed by the Surveyor-General's Department.

An important incident of the year was a tentative forecast of the character of the monsoon season, made by Mr. Eliot (who officiated for Mr. Blanford during his absence on furlough). The retardation of the monsoon rains in 1878, following on their almost complete failure in the North-West Provinces in the previous year, was a cause of grave anxiety. Mr. Eliot's opinion, on examination of the whole subject, was that the advent of the rains would probably be retarded, but that they would be more equally distributed than in previous years. This prediction was borne out by the results.

The work sanctioned by the Secretary of State in 1875, of copying the ship observations relating to the Indian seas that had accumulated in the Marine Department of the London Meteorological Office, was fast approaching completion, and by it the basis of a knowledge of the general meteorology of the adjacent seas, comparable to the existing knowledge of the land observatories, was being laid. The observations of the Department had finally dissipated some of the long prevalent errors respecting the Indian monsoons, such as, for instance, the idea that the summer monsoon of India is caused by the heat of Central Asia, and blows towards that region. But with respect to the seas, there was still no accurate knowledge of the origin of the summer wind, and it was still doubtful whether the general body of the southern trade winds crossed the equator and fed the monsoon, or whether, on the other hand, the North Indian Ocean was not the chief source of the vapour supply, and the connexion of the monsoon with the southern trades only fortuitous and partial. Another problem awaiting solution in the study of the meteorological marine logs was the possible deficiency of pressure over parts of the ocean as bearing on land droughts such as those of 1876.

Owing to the increasing attention attaching to the connexion between solar physics and meteorology (a matter discussed so long ago as the beginning of the century by Sir John Herschel), Mr. Blanford entered into communication with Professors Norman Lockyer and Balfour Stewart, and, at their suggestion, obtained the Secretary of State's sanction for the purchase of a new form of actinometer for

measuring the solar heat. Mr. Blanford also took the opportunity during his stay in Europe to study and practise the process of solar photography as elaborated on a large scale by Mr. Janssen, the Director of the Physical Observatory at Meudon.

Mr. Meins, a trained solar photographer, had been despatched to India in 1877, and was engaged in taking daily photographs of the sun's disc up to the date of his death in 1879. This unfortunate event caused a delay of nine months, but at the close of 1879, Sergeant White, of the Royal Engineers, was sent to India to continue the work, under the superintendence of Mr. J. B. N. Hennessey, M.A., F.R.S. A large photo-heliograph, suitable for taking pictures of the solar disc 12 inches in diameter, was subsequently supplied to the Dehra Observatory under the direction of the Surveyor-General's Department (*see* page 234).

The Report on the Meteorology of 1877 was prepared by Mr. Eliot. Like the Reports of the two previous years, it included a general description of the meteorological features of the year, with comparative tables showing the average values of the several meteorological elements derived from past years, and the anomalies or differences in 1887, descriptions of the newly-established stations, and the geographical co-ordinates and elevations of all stations. The report was illustrated by 12 charts in coloured lithography, showing the mean distribution of temperature, atmospheric pressure, and wind direction in each month of the year. According to a notice in the Journal of the Austrian Meteorological Society, under the very competent editorship of Professor Hann, the annual volume on the Meteorology of India at this time already ranked with that of the Russian Empire in the extent and comprehensiveness of its data, while it appeared at a very much earlier date.

Part III. of the Meteorological Memoirs was issued in 1879, containing the following papers :—

1. On the variations of rainfall in Northern India by S. A. Hill, B.Sc.
2. Meteorological and hypsometrical observations in Western Tibet, recorded by Dr. J. Scully, with a discussion by Henry F. Blanford.

Mr. Eliot also published a Report on the Madras cyclone of 1875.

The year 1879–80 completed the first *lustrum* of the existence of the Department. Up to March 1880, 117 stations in India and neighbouring countries had been established, not including the

observatories in Ceylon. There still remained, however, some portions of the country in which they were somewhat sparsely scattered, but most of these were the wilder tracts where no suitable stations existed.

The Famine Commission Report issued during the year 1880–81, gave emphatic expression to the objects of the department and the practical importance of meteorology. After giving a summary of what is known respecting the distribution of rainfall in India and the variations to which it is subject, the Commissioner remarked :—

"As at present no power exists of foreseeing the atmospheric changes effective in producing the rainfall, or of determining beforehand its probable amount in any season, such as would admit of timely precautions being taken against impending drought, the necessity becomes the greater for watching with close attention the daily progress of each season as it passes, for ascertaining with accuracy and promptitude the actual quantity of rain in all parts of the country, and for forming the best and earliest judgment possible from the facts as they occur, whether the supply will be sufficient or otherwise. For the present, at least, as far as the rainfall directly affects the subject under consideration, these are the only precautions that appear possible. Within the last few years a very satisfactory system of meteorological observations has been established all over British India, and, in our opinion, it is of primary importance that it shall be maintained in complete efficiency, and shall so far be strengthened and improved as to ensure the early and punctual supply of information to the executive Governments, and to the officials in all departments concerned with the agriculture of the country, or the preparations required to meet famines, as to the actual progress of the periodical seasons of rain in all parts of the provinces, for which these Governments or officers are respectively responsible. So far as it may become possible with the advance of knowledge to form a forecast of the future, such aids should be made use of, though with due caution.

"We are also satisfied of the importance of the diffusion of more sound and accurate knowledge of the causes and mode of occurrence of the periodical rains, on which the well-being of India is so largely dependent, not only among the officers of the Government but also among all classes of the community. Any measures which the Government may find possible with a view to the publication and diffusion of such knowledge cannot fail to be highly beneficial."

In the annual return of the rainfall prepared in 1879 for the information of the Secretary of State, considerable tracts were unrepresented, owing to the absence of registers. Measures were therefore taken during the following year to supply these deficiencies, and to establish rain-gauge stations in the Tributary Mehals of Orissa, Chutia Nagpur, South Rewa, the eastern districts of the Central Provinces, Jaipur, Bastar, and also in Khairpur, on the borders of Sind. An endeavour was made to do the same in Western Rajputana. Rainfall registers for the past six years were also obtained from several stations in Haidarabad, so that this territory was as well represented as most other parts of India.

A system of storm-warning, by means of telegraphic report to Bombay from seven stations on the west and three stations on the east coast, was brought into operation on the 13th June, the inclusion of eastern stations being rendered necessary, as it was known that the storms which are felt on the west coast of India originate in many cases over the Bay of Bengal. In Bengal an improvement in the provincial system of reports was introduced by Mr. Eliot, the number of stations sending daily telegrams to Calcutta being increased from 7 to 15. All with the exception of Dacca were situated on the coasts of the Bay of Bengal. Arrangements were also made for lithographing the Calcutta daily reports and issuing them about 3 p.m. to the port authorities, the chamber of commerce, merchants, and newspapers. The reports were accompanied by a lithographed chart of the Bay of Bengal.

The observations of the temperature of the ground at Alipore, at the surface, and at depths of 1 foot and 3 feet respectively, disclosed the fact that the mean annual temperature of the ground was not less than 5° in excess of that of the air. These observations also showed that the ground acts as a reservoir of the heat received from the sun, which it stores up and slowly gives forth to the atmosphere. Subsequent research showed that the ground temperature is subject to slow but not inconsiderable fluctuations, which depend evidently much more on the rainfall than on any variation in the radiant intensity of the sun. The importance of these deductions, from an agricultural point of view, led to the institution of similar observations at Allahabad.

The remaining portion of the observations extracted from the meteorological logs in the possession of the London office was received in 1880–81. It consisted of all the observations recorded in Indian seas north of the equator, between East longitude 50° and 100° up to the end of the year 1878, and the data were reduced, corrected, and tabulated according to the months and squares of 1° latitude and longitude, and arranged in 154 data books, one for each 10° square in each month. The discussion of this large mass of material therefore now became possible, and was eventually undertaken by a special officer, Mr. Dallas, who had been trained in the London Meteorological Office, and was appointed, partly for this purpose, in 1882.

Part IV. of the Indian Meteorological Memoirs was published during the year. It contained a paper by Mr. F. Chambers on the winds of Karachi, being a discussion of three years anemographic

records at that station, illustrated by eight plates. Mr. Hill published a table giving the monthly total rainfall at each station in the North-West Provinces for 1880, the number of rainy days in each month and the average monthly rainfall of each place.

Owing to the prevalence of haze in fine dry weather, the actinometric observations taken for two years at Alipore were less successful than had been hoped for, and on the recommendation of the Solar Physics Committee, Leh, in Ladak, was selected as being situated, as was hoped, in a clearer atmosphere and at a height above the disturbing influences of the haze of the plains.

During the year Mr. Eliot devised a new and improved system of storm signals for the port and signalling stations on the Hugli, below the port. The knowledge of such storms had by this time advanced sufficiently to enable Mr. Eliot to a certain extent to predict their course, a matter of great importance to outgoing ships. The new system of signalling made provision for this special information. In connexion with the Bombay storm-warning system Mr. F. Chambers drew up an interesting list of some 70 storms of the west coast, which was published in Vol. II., Part 1, of the Indian Meteorological Memoirs.

In 1881 Miss E. Isis Pogson was appointed meteorological superintendent to the Government of Madras, a step which resulted in the prompter transmission of the Madras registers to headquarters, and less delay in the preparation of the annual report.

The first volume of the Meteorological Memoirs was completed by the publication of Parts V. and VI., containing two papers by Mr. Hill on the Meteorology of Allahabad and on that of the North-western Himalaya, and a discussion of the hourly observations of the barometer at Goalpara, Patna, and Leh, by Mr. Blanford.

The following year was marked by efforts to obtain information respecting the extent and thickness of the Himalayan snows, a physical feature which appeared to exercise considerable influence on the meteorology of the plains, and to which attention was first directed in 1877. In April 1882, a communication was made by the Government of India to the local governments of the northern provinces, requesting that the attention of the civil officers and Residents of Hill States might be particularly directed to this matter, and it was recommended that monthly reports on the state of the snows on the passes and higher ranges of the interior should be drawn up from information obtained from native traders, travellers, and others, and communicated to the central office.

The observed facts are thus described by Mr. Blanford :—

"A fall of snow on the hills is followed, as soon as the weather clears, by a considerable rise of pressure over the mountains, and frequently also over the north-western plains, and this rise is accompanied by a steady wind on the plains, from north along the foot of the hills; from north-west on the more distant plains. In the cold weather and early spring, when there is often rain simultaneously on the plains, there is also a considerable fall of temperature; but in April frequently, and generally in May, there is no rain on the plains, and any fall of temperature is restricted to the immediate neighbourhood of the hills. In these months the cooling effect of the snow is local, but it is also persistent; and since the snow reflects a large portion of the sun's rays, and that which is absorbed does not raise the temperature of the surface, nor that of the air resting on it, above the freezing point, this air remains denser than it would be over a bare rock surface. It floats away as a north-west wind at a high level, towards the plains communicating its high pressure and southward movement to the lower strata, and thus the whole mass of dry air moves towards the region of low pressure (which then exists over the plains of Behar, Bengal, and the peninsula), constituting the dry land winds, usually characteristic of the spring, and in seasons of unusual snowfall lasting into the summer months. These winds are hot, the heat being absorbed from the dry strongly-heated land surface, and the lower strata, thus heated, mingle by convection with the higher, while the latter descending are also heated, partly by the compression, which the air necessarily undergoes, partly by being brought within the heating influence of the ground."

During the same year a chart of the average rainfall of India was drawn on a map of 64 miles to the inch and displayed at the Amsterdam Exhibition, and also prepared for reproduction by lithography. The chart accompanying it shows the names of 985 places, with the average rainfall of each to the nearest integral inch, while the distribution of rainfall is shown by eight tints, representing respectively the areas with an annual fall below 5 inches and successive increments up to above 100 inches. The only general rainfall charts of India previously published were, first, that drawn in 1872 by Dr. (now Sir) D. Brandis, the late Inspector-General of Forests, when engaged in the preparation of his work on the Indian Forest Flora, and published in Vol. II., No. 7, of *Ocean Highways*, and, second, a revised edition of the same chart, prepared in Mr. Blanford's office and published in 1878.

Progress was made by Mr. Blanford with the discussion of the rainfall data of past years and by Mr. Eliot in the study of the origin and development of storms, by his paper (printed in Part I., Volume II., of the Indian Meteorological Memoirs) on a small cyclonic storm which originated over the Bay of Bengal, and thence travelled northwards across Bengal in the third week of November 1878. He showed that the origin, existence, and motion of the storm were due entirely to the atmospheric conditions of the area

which it actually traversed, and the course of the cyclone across Bengal took place where the air-motion was relatively least, prior to its advent.

The arrival of Mr. W. L. Dallas, appointed Scientific Assistant to the Meteorological Reporter to the Government of India, enabled the important work of reducing and discussing for publication the marine meteorological observations collected during the 20 years 1856–75 by the London Meteorological Office to be taken up, and a beginning was made with the barometic and wind data of the Bay of Bengal for the month of January.

With regard to the collection of current meteorological data for the Bay of Bengal this was undertaken by Mr. Eliot. Observations were regularly recorded with duly verified instruments on board the light-ships off the mouth of the Hugli, and a form of return showing the meteorological information which it is desired to obtain was handed to the captain of every vessel. A large number of captains duly responded to this appeal, and information of great value was derived from their returns On the whole the extracts proved that the weather in the whole extent of the bay (excluding the Andaman sea) was fairly indicated by the observations taken at the coast stations, and that the progress of every important storm might be traced and followed with more or less exactness, almost from its origin, from the shore observations.

Among the more important incidents of the year 1883–84 should be mentioned the arrival of Sergeant Rowland and Mr. Shaw at Leh, in November 1883, for the purpose of instituting actinometric observations there. For some months previously they had been undergoing most valuable training at the hands of Mr. Hennessey at Dehra.

A body of valuable information with regard to the question of the influence of the Himalayan snowfall on the dry westerly winds in Northern India was obtained from officers stationed in the Hill States, and the abnormal features of the snowfall in the spring and winter months enabled Mr. Blanford to frame forecasts with regard to the duration and nature of the dry winds in the plains, which were fairly justified by the events. During the year observatories were established at Kailang, in Lahul, at an elevation of 10,000 feet above the sea, and to the north of the second survey range, and also at Chamba.

Among the more notable publications of the year were Part II. of Vol. II. of the Indian Meteorological Memoirs, containing a memoir

by Mr. Blanford on the storms of the west coast and on the land-formed cyclone of Gujrat of July 1881, and a very important paper by Mr. Hill on the normal temperature of Northern India.

The observatories in existence in 1880-85 were classified by Mr. Blanford as follows :—

Low-level observatories in India.
Hill observatories.
Himalayan valley observatories.
Extra-Indian observatories.
Ships.

Of the first four classes there had been 117 in 1880, and these were increased to 128 in 1885, exclusive of 22 observatories in Bengal, which were established in connexion with the provincial system of telegraphic weather report.

The actinometric observations at Leh, after 17 months, did not prove so successful as had been anticipated, for owing to the cloudiness of the skies, Leh turned out, during a large part of the year, to be even a less favourable station than Mussoorie. Fifty-two complete sets of three daily observations and six long series, together with 64 imperfect sets of the former and 14 of the latter, were the total result of the 17 months' work. It was, therefore, deemed inexpedient to continue the experiment, and arrangements were made for Sergeant Rowland and Mr. Shaw to return to India at the close of the season.

Before 1884 all the officers of the department had been Europeans, who had either received a special education in science or had been trained in the technical work of a meteorological office. During that year it was resolved as an experiment to train an educated native to prepare the daily weather reports. Lalla Ruchi Ram Sahni, a native of the Punjab, who had taken his B.A. degree in Physical Science and had passed for an M.A. degree, was selected for the post.

In the spring of 1884 the snows on the North-Western Himalayas were more extensive and later than they had been in any previous year since 1878, and Mr. Blanford, predicted a somewhat retarded or weak and interrupted monsoon. So far as the rains of the early part of the monsoon of North-Western India were concerned the forecast was fully justified by the events. After a general burst in the latter part of June the rains of all Western and North-Western

India were entirely suspended for three weeks or more, and even up to August they were somewhat defective in the Punjab. But the conditions there existing did not operate throughout the whole of the monsoon and the latter months brought abundant rain. Nothing was said in the forecast respecting the deficiency of the Bengal rainfall in the latter part of the season, nor that of the Deccan and Carnatic. The causes of that deficiency were obscure, and, therefore, reserved for future investigation.

On the 26th July 1884, heavy floods occurred in the rivers Tapti and Narbada, which resulted in the submergence of a portion of the city of Surat. These were followed on the 31st by the flooding of the Subarmati, Mahi, and neighbouring rivers which discharge into the gulf of Cambay, causing serious breaching of the Bombay and Baroda Railway. Again, on the 3rd September, the same rivers were in flood with like disastrous consequences. All these floods, and also a flood which occurred in September 1882, were the consequences of small cyclones of the south-west monsoon type, which either travelled to Western India from Bengal or the Central Provinces, or in the last instance had travelled up the west coast at the end of August. It was accordingly arranged that the superintendents of observatories situated near the head waters of the Tapti and Narbada should be instructed that in the event of the rainfall exceeding 3 inches in the 24 hours an urgent telegram should be sent to certain Bombay officers, and also that premonitory warnings should be sent from the Simla, giving notice of the approach of a storm to the Central Provinces, Central India, and Gujrat. At the same time the Meteorological Reporter from Western India was requested to take up the question of the floods and investigate the circumstances attending their origin, with a view to the greater efficiency of the system.

An important addition was made during the year under review by Mr. J. Eliot to his previous admirable work on the law of storms. Taking as his basis the daily weather charts of India, drawn up in the office since 1877, he took out the track of every storm generated over the Bay of Bengal between the months of May and December, during the five years 1877–81 (46 in all), and discussed them in a memoir of 216 quarto pages, illustrated by seven plates, issued as Part IV. of Vol. II. of the Indian Meteorological Memoirs.

In regard to marine meteorology, Mr. Dallas completed, during 1884–85, the set of monthly charts showing the distribution of barometric pressure, the prevalent winds, and marine currents of the

Bay of Bengal. The January chart was lithographed on a reduced scale as a specimen of the work, and circulated to the port officers, Marine Weather Institutes, and some ship commanders for criticism, some valuable suggestions being offered in reply.

Up to 1885 the daily weather reports had been issued at Simla from the 1st May to the 1st October, and at Calcutta during the cold season, but in this year it was arranged for the work to be carried on permanently at Simla in future.

Before 1885 there were only three observatories fully equipped with autographic instruments for furnishing either a continuous register or one repeated at short intervals: these were the Government observatories at Calcutta (Alipore), Bombay (Colaba), and the Maharajah's observatory at Jaipur. During 1885–6 a fourth was established at Allahabad, and a portion of the instruments for a fifth at Lahore were received shortly after, a suitable building having been already provided.

Some further additions were made to the stations transmitting regular returns of rainfall to the Central Office, some being of especial value as representing the arid region of Western Rajputana, which but a few years since was an almost complete blank on the charts of recorded rainfall. Improved returns of the Himalayan snowfall were also received from hill stations on the north and western frontiers.

Attempts had been made to estimate the prospects of the monsoon rains from the snowfall reports, and the wind and pressure distribution in the period immediately before the rainy season in each of the preceding two or three years. In 1885, Mr. Blanford's prediction on the 21st May was that the influx of the monsoon rains on the west coast and in Southern and Western India generally would be retarded, and this was amply borne out by the subsequent history of the season.

Some time before Dr. Brandis's retirement from the office of Inspector-General of Forests with the Government of India, he conferred with Mr. Blanford as to the establishment of observatories in connexion with the forests, with a view to ascertaining the effect of forests more especially on temperature and rainfall. As a result an observatory was established at the Forest School at Dehra Dun, which should serve as a model for the forest observatories and also as a training school for observers. In July 1884, the first pair of comparative observatories was started at the Forest Nursery, Ajmir, in the following years various other pairs were established near

Ajmir and Dehra. The tendency of the results was to show that the existence of forest increases the rainfall. Mr. Ribbentrop, the officiating Inspector-General of Forests with the Government of India, starting from the fact that extensive tracts of forest, previously devastated by jungle fires with a view to the nomadic system of cultivation practised by the hill tribes, had been brought under protection in 1875, and that thereby the area of vigorous forest growth had been enormously increased, was led to inquire whether this measure had sensibly affected the rainfall. Mr. Blanford's data showed that the rainfall of the years subsequent to 1875, when compared with that anterior to that date, manifested a large increase, attributable to the preservation of forests. Subsequently, however, some doubt was thrown on the trustworthiness of the registers of the earlier years, which had led to this conclusion.

On the 22nd September 1885, a cyclone, small in extent, but accompanied by a high storm, devastated the settlement of Hukitolla, at False Point, in Orissa. The terrible destruction of life and property which resulted from this storm, aroused public attention to the subject of storm warnings to the coast ports, and led to the adoption of measures for extending the system. It was therefore arranged that whenever the telegraphic reports showed the existence of a storm over the bay, an intimation to that effect should be sent to the port officers of the chief places on the Indian coast, who should be instructed to depend on their own observations of the wind and barometer for taking all necessary precautions.

During 1885–86, Part I. of Vol. III. of the Meteorological Memoirs was issued, containing the first part of a memoir on the rainfall of India. Three other memoirs, viz., one by Mr. Eliot, on the Akyab cyclone of the 12th to the 17th May 1884; one by Mr. Blanford, on the diurnal variations of the rainfall of Calcutta; and one by Mr. Dallas, on the meteorology of a sea tract to the south of the Bay of Bengal, were also printed.

As a consequence of the annexation of Upper Burma, an enormous tract of country, of the meteorology of which scarcely anything was previously known, was in the same year brought under the operations of the department. Three fully equipped meteorological observatories were established at Mandalay, Bhamo, and Kindat, and in addition rainfall registers were received for a portion of the year from ten other stations. The three principal observatories, however, very inadequately represented the enormous tract added to our possessions, and it was felt that it would be soon necessary to

increase their number. One other observatory commenced work during the year, *i.e.*, at Coco Island, which, being situated between Diamond Island and Port Blair, and close to the cradle of most of the violent storms that occur at the change of the monsoon, formed a valuable addition to the Indian system.

Preparations were also made for establishing an observatory at Baghdad, in connexion with the British Political Residency, and proposals were also afoot with respect to a fresh observatory at Srinagar. A third rainfall register from Baluchistan (*i.e.*, from Pishin) was obtained, so that the Baluch highlands were thus represented as adequately as other parts of India.

The investigation of the vicissitudes of Indian rainfall, made by the light of all the numerous rainfall registers that had accumulated in the Meteorological Office relating to the last 22 years, were concluded during the year under review. The result shows that in the Carnatic there is really a tendency to drought at intervals of about 11 years, but not necessarily of such intensity as to be disastrous. In all other parts of the peninsula such regularity was not shown by the numerous registers consulted. But this appeared to arise from the cyclical variation being much more liable to disturbance by seasons of copious or deficient rainfall, which are due to other and non-periodic causes. The most important law relating to the droughts of previous years in Northern India, and which appeared to hold good equally of temporary and prolonged suspension of the rainfall, was that they were preceded by heavy snowfall on the Himalaya, particularly the North-west Himalaya. Such was the case before the famines of 1868, 1877, 1878 (Kashmir), and also in the period preceding the temporary droughts of 1880 and 1883.

A volume of weather charts of the Bay of Bengal, exhibiting the barometric pressure, winds, and currents prevalent in every part of the sea, and as far south as the equator, in each month of the year, was published during 1886–87. The work was prepared by Mr. Dallas, from the data furnished by the meteorological logs collected by the London office between 1855 and 1878 and copied, tabulated, and reduced at the cost of the Government of India. Each chart was reduced to convenient dimensions, and accompanied with a page of description, giving statistical and other details. These publications have been much appreciated by the naval and mercantile marine.

Mr. Hill communicated to the Royal Society an important paper on "Some anomalies in the winds of Northern India, and their "relations to the distribution of barometric pressure," * which was published in the Philosophical Transactions.

In May 1887 Mr. H. F. Blanford went on furlough, and Mr. J. Eliot acted as meteorological reporter to the Government of India, Mr. Pedler acting as reporter to the Bengal Government. Shortly after taking charge, Mr. Eliot was asked to submit proposals for the more efficient working of the department. Mr. Eliot's report was duly submitted to Government, together with a memorandum from Mr. Blanford approving most of the suggestions. After some delay, Government sanction was eventually given to various changes, of which the following were the most important:—

(*a.*) The discontinuance of the solar and terrestrial radiation observations, except at a few selected stations;

(*b.*) The adoption of 8 a.m. as the hour for the observations embodied in the weather telegram transmitted daily to Simla, Calcutta, and Bombay;

(*c.*) The tabulation of all the observations hitherto recorded, in a form admitting of easy reference, and the calculation of daily averages of air pressure, maximum and minimum temperatures, aqueous vapour pressure, cloud, and rainfall.

(*d.*) The extension and improvement of the methods of collecting rainfall data for the information of the Government of India, and the adoption of a uniform system of rainfall registration throughout India.

These changes were all recommended on well considered grounds, which were explained at length by Mr. Eliot. For instance, with reference to the collection of rainfall data, he pointed out that the rainfall stations communicating with the Imperial Government were only 497 in number in all, while those communicating with the provincial governments were 1,390 in number. Next, there was an utter want of uniformity in the hours and methods of rainfall observation. The measurement of rainfall was initiated, like so many other Indian institutions, provincially under the revenue authorities, and it had never been systematized for the whole of India. A striking instance of the difficulty and inconvenience of

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* An abstract of this was published in Proceedings of the Royal Society for January 1887.

dealing with unsystematized observations cropped up in connexion with the question of the influence of forests on rainfall. The rainfall statistics of the Central Provinces for the previous 20 years, if they could be accepted as true, would have established most conclusively that the extension of forests had been accompanied by a marked increase in the average rainfall of the forest districts. But when Mr. Blanford proceeded to make further inquiry into the value of these rainfall returns, the Chief Commissioner for the Central Provinces in his reply had to acknowledge that, owing to the uncertainty as to the gauges used in past years and the carelessness in registration, the records were unreliable. The effect of this unsystematic registration was to postpone the decision as to the influence of forests on rainfall in that area for another 20 years.

Improvements were also made by Mr. Eliot in the daily weather report, which was in future to be accompanied by a chart. By the 1st April 1888, copies were issued to 228 Government officers in all parts of India, and to a limited number of meteorological bureaux and authorities in Europe and America. The daily weather report and chart in its new form compared not unfavourably with those published by the meteorological departments of England, France, Italy, Algeria, Austria, Germany, Australia, and the United States. It also possessed a special value as dealing almost entirely with a tropical region, and one where the most striking example of the semi-annual system of south-west and north-east monsoons occurs.

In November 1886 the duty of issuing storm warnings to the Burma and Madras ports was entrusted to the meteorological reporter to the Government of Bengal, and this had been accepted by Mr. Eliot, with the proviso that certain arrangements should be made for rapid telegraphic communication between the Calcutta weather office and the distant port officers and observatory superintendents at the Burma and Madras ports during stormy weather.

The charts of the Arabian sea, prepared by Mr. Dallas from the data collected by the Board of Trade from ships navigating that sea during the period 1855–78, were published during the year 1887–88, in exactly the same form as the charts of the Bay of Bengal. Part IV. of Volume IV. of the "Indian Meleorological Memoirs," giving a list of storms during the years 1882–86, with brief descriptions similar to the list published in Part VI., Vol. II., and intended as a continuation of that list, bringing the information up to date and followed by a full account of

the three cyclones of November and December 1886 in the Bay of Bengal, was issued in February 1888. An account of the Balasore cyclone of May 1887 was prepared as the first part of a new publication of the Department, called the "Cyclone Memoirs."

Special attention was paid by Mr. Eliot to the condition of the barometers used at various stations, and steps taken to remedy the irregularities discovered.

In publishing the summary of the winter snowfall, and the monsoon forecast based chiefly upon it, Mr. Eliot announced in the first week of June 1887 that the general indications were favourable in North-east and North India, and somewhat unfavourable in Southern India. He predicted early and abundant rain in Northern India, and more especially in Upper India, and more or less deficient rains in the Poona, Sholapur, Belgaum, and adjacent districts. The forecast was in general agreement with the actual character of the monsoon.

During 1888–89 there were some important changes effected in the Department. Part of these had been sanctioned tentatively in the previous year, and as they were found to work smoothly, Mr. Eliot eventually submitted his final proposals, which were sanctioned with effect from the 1st January 1889. They were as follows:—

(I.) The permanent retention of 8 a.m. as the hour for the observations telegraphed daily to Simla, Calcutta, and Bombay for the various daily weather reports issued by the Department, and the discontinuance of the 10 a.m. and 4 p.m. observations at 88 of the 157 observatories maintained by the Department. The change of the general hour of the morning observations from 10 a.m. to 8 a.m. enables the Simla Office to issue the daily weather report in the afternoon of the same day, and the Bengal reporter to issue the Bay of Bengal report at about 11 a.m. or at the beginning of the office day to Calcutta merchants, shippers, &c. The acceleration in the publication of the daily reports was much appreciated in Calcutta and Bombay, as well as by the Government of India.

A great change was also made with regard to the returns used for scientific discussion in the annual report. Inasmuch as in the case of 88 stations the previous records were vitiated, owing to careless observations or imperfect instruments, it was decided to discontinue the 10 and 16 hours observations at these stations, and to continue them only at the remaining 69 stations, the meteoro-

logical returns of which could be accepted as of the highest standard of accuracy, and as forming a reliable basis for scientific discussion in the annual report. This had the effect of increasing the accuracy of the report, diminishing its bulkiness by more than half, and considerably expediting its appearance.

In consequence of these changes, the following re-classification of the observatories became necessary :—

1st.—*First class Observatories,* including Calcutta, Allahabad, and Lahore, at which continuous registration is effected by automatic methods, and Mussoorie or Simla, at which special actinometric observations of a strictly scientific character are taken.

2nd.—*Second class Observatories,* at which a set of observations is taken daily at 8 a.m., and telegraphed to Simla, Calcutta, or Bombay, for the preparation of the daily, weekly, and monthly reports, issued as early as possible for the information of the public, and two sets of observations daily at 10 a.m. and 4 p.m.

3rd.—*Third class Observatories,* the great majority of which will take daily a set of observations at 8 a.m. only, to be telegraphed to Simla, Calcutta, or Bombay.

The other important changes sanctioned were :—

(II.) The permanent adoption of the system of telegraphing rainfall information to Simla introduced tentatively in 1888, and the establishment of a uniform system of rainfall registration throughout India.

(III.) The permanent transfer of the working and control of the Bombay Coast Storm Signal Service to Simla and the establishment of a local system at Bombay, in order to give early weather information to the commercial community of Bombay.

In connexion with this, arrangements were made by Mr. Eliot for the preparation at Bombay of daily weather reports and charts similar to those prepared in Calcutta, and Mr. Hutchinson, who had succeeded Mr. Chambers in the local reportership for Western India, was initiated into the methods employed at Simla and Calcutta. The first report issued to the Bombay public was that for Monday, 14th May 1890. It found much favour with the Chamber of Commerce, who, with the Government, found the funds for the undertaking.

(IV.) The extension of the existing system of collecting meteorological information from the captains of vessels navigating the Arabian Sea and the Bay of Bengal. The necessity for the extension of the work of observation in this direction had been long recognised. It is absolutely essential for the investigation of the causes of the origin of cyclonic storms. Hitherto information had been mainly sought of the weather during cyclones, but not of the antecedent weather and conditions which led up to and originated these storms. Information of the weather in the Indian Seas is even more necessary in dealing with the causes which affect the strength of the great rain-giving currents of the south-west monsoon. These currents advance from the sea into India, and their strength and variations of strength probably depend as much upon conditions in the sea area from which they advance as in the land area of India itself. It was hence necessary that observations of the weather in the sea area should be collected as regularly and systematically as for the land area.

(V.) The introduction of arrangements for the collection of special observations during storms, and the recognition of these observations as part of the duties of observers by special payments for these observations. The work of observation with regard to storms had been previously very defective. It was recognised in the rules drawn up many years before by Mr. Blanford for the guidance of observers that it was part of their duties to take frequent observations during storms but they neither received any pay for this special work, nor was any deduction made from their pay, if they neglected the duty of taking these observations. It was hence voluntary unpaid work, and as its performance was attended with much physical discomfort, it was almost entirely neglected. As, however, storms form on the whole the most important feature of the weather, the registration of meteorological observations during their existence was clearly as absolutely essential as of the regular observations.

(VI.) The introduction of arrangements for the utilisation of the services of duly qualified scientists in Europe for the discussion of some of the more important series of observations which have accumulated in the Calcutta Office during the past 13 years. This was rendered necessary by the great increase of work thrown on to the Simla and Calcutta Offices. Among several

important complete series of observations in the Calcutta Office awaiting discussion were the following:—

(1.) Hourly observations taken during a large number of years (varying from 10 to 13) at 26 second-class stations. These observations have cost Government upwards of a lakh and a half of rupees.

(2.) Anemographic observations taken for several years at 14 stations in different parts of India by means of self-recording instruments.

(3.) The continuous series of observations taken at Alipore, Allahabad, and Jaipur during past years by self-registering instruments.

In order that these observations, accumulated at much cost and labour, should be promptly utilised, Mr. Eliot suggested the adoption of the plan already been tried by the Geological Survey Department and found to work very satisfactorily. There are several distinguished meteorologists in Europe who have ample leisure for the discussion and investigation of any of the series of observations in the previous list, and would probably be glad to undertake the work for a moderate remuneration. An annual grant was therefore sanctioned by Government for this purpose.

(VII.) The re-adjustment of work and establishments at the central and local meteorological offices, and the adoption of certain changes for increasing the efficiency of the Calcutta and Simla offices.

The following parts of the Indian Meteorological Memoirs were issued during 1888–89:—

Parts III. and IV. of Vol. III., completing Mr. Blanford's very valuable monograph on the rainfall of India. Part V. of Volume IV. containing an account of the cyclone of May and June 1881 in the Arabian Sea, drawn up by Mr. Chambers.

The Handbook of Cyclonic Storms in the Bay of Bengal for the use of Sailors has also been issued recently. The following were also prepared:—

1. Account of the cyclonic storm of August 1888, prepared by Mr. Pedler. This will form Part II. of the Cyclone Memoirs.

2. Account of the cyclonic storms of September 13th to 20th, 1888, and of the cyclone in the Bay of Bengal and the Vaitarna storm in the Arabian Sea in October and November 1888, drawn up by Mr. Eliot. This will form Part III. of the Cyclone Memoirs,

and will, with Part II., give an account of the most important cyclonic storms of the year 1888 in the Indian seas.

3. A short paper by Mr. Dallas on the relation between sunspots and weather as shown by meteorological observations taken on board ships in the Bay of Bengal during the years 1885-78.

4. An account of the storm of the first week of June 1887, in the Arabian Sea, compiled by Mr. F. Chambers.

The present arrangements for issuing storm warning signals are the following:—

Ports on the Burmah, Bengal, and Madras Coasts warned by the Bengal Reporter:—

(a.) *Bengal ports*—
- Calcutta and River Hooghly.
- Chittagong.
- Orissa ports, including Pooree, False Point, Chandbally, and Balasore.

(b.) *Burmah ports*—
- Moulmein.
- Rangoon.
- Bassein.
- Akyab.

(c.) *Madras ports*—
- Bimlipatam.
- Gopalpur.
- Vizagapatam.
- Cocanada.
- Masulipatam.
- Madras.
- Negapatam.
- Tuticorin.

Ports on the West Coast of India warned by the Bombay Reporter:—

(a.) *Bombay ports*—
- Karachi.
- Bhaunagar.
- Daman.
- Bombay.
- Ratnagiri.
- Goa.
- Karwar.
- Vingorla.
- Kumta.

(b.) *Madras ports*—
- Cochin.
- Mangalore.
- Calicut.

During a cyclonic storm which crossed the coast of Kathiawar in the early part of November 1888, the coasting steamer *Vaitarna* was lost, and the court of inquiry recorded the opinion that if a proper storm-warning system had been in force, with communications to most of the northern ports, intimation could have been conveyed in time to have enabled the *Vaitarna* to avoid the cyclone. This was a striking proof of the seriously defective organisation of

the Bombay system, and prompt remedial measures were taken as far as possible by Mr. Eliot. A local daily weather report and chart is now published and issued daily; a new storm signalling system has been devised, and steps have been taken to improve the representation of Kathiawar in the meteorological system.

On the 8th May 1889, Mr. H. F. Blanford retired, after a connexion with the Meteorological Department of 22 years. He was appointed Meteorological Reporter to the Government of Bengal in June, 1867, and initiated the local meteorological system and the storm warning service for the port of Calcutta after the experience of the cyclone of October 1864. When it was determined to combine the various provincial systems into a common Meteorological Department for the whole of India, Mr. Blanford was called upon to report on the best means of carrying this into effect. His suggestions were approved, and he was appointed Meteorological Reporter to the Government of India. The series of Annual Reports and Papers written by him for the Indian Meteorological Memoirs form a most valuable contribution to meteorological science. Since his retirement he has published "A Practical Guide " to the Climates and Weather of India, Ceylon, and Burma, and " the Storms of the Indian Seas," which gives an admirable summary of the results of meteorological observations taken in India, and presents in a clear and interesting manner the more important features of the climates and weather in India. The Government expressed its high value of his services in the following terms:—

"I am to take this opportunity to record the high estimate which has been formed by His Excellency the Governor-General in Council of the zeal and ability displayed during the several years of his incumbency of the office of Meteorological Reporter to the Government of India by Mr. Blanford, who has now retired from the service, and who was practically the founder of systematic and uniform meteorological observations in India."

During 1889–90, six third-class observatories were established within India itself, while observations were also obtained for the first time after a long interval from the observatory at Trivandrum maintained by the Maharajah of Travancore, and from that at Bhavnagar maintained by the Thakur of that State. Voluntary observatories were established at Shortt's Island near Chandabally, and at Lungleh in the Chittagong Hill Tracts, during the past year, and useful observations obtained therefrom. From the distant station of Zanzibar some excellent observations were obtained for over a year from Dr. Charlesworth, the Medical Officer, but he was then, unfortunately, invalided home, and Mr. Eliot thinks it may

be well, under the circumstances, to devote the cost to maintaining fresh observatories in Burma. At the Seychelles, another distant and isolated station, arrangements were made for joining with the Director of the Mauritius Meteorological Service, and so obtaining improved observations. A set of instruments were supplied in March 1888 to Dr. Woolbert, Medical Officer attached to the military officers on special duty on the Perso-Afghan frontier, in order that a series of observations might be taken at Mashhad, on the Perso-Afghan frontier. These have been received from September 1889, and are of very considerable interest. Mr. Eliot has also taken steps to establish observatories at Perim and Paumben. The former is much wanted in order to furnish meteorological data of the southern part of the Red Sea, of which is not sufficiently representative, and the latter in connexion with the Bay of Bengal Storm-Signal Service. Additional observatories are much wanted in Burma, in order to elucidate the meteorology of that area, and ascertain the part it plays in deflecting the south-west current of the Bay of Bengal, and in producing variations in its strength, and the distribution of rainfall in North-East India. But it is undesirable to open out new observatories in that province until railway or telegraphic communication has been extended to all the more important districts. Certain parts of India too are imperfectly represented, for instance, the north-west coast of Kathiawar, certain parts of the Deccan (North-East Haidarabad), the eastern districts of the Central Provinces, and certain portions of Chota Nagpur, Rajputana, and Central India.

Progress is being made in the introduction of a uniform system of rainfall registration, and in 1889 a common hour, 8 a.m., was adopted. Rainfall charts and statements of a far more comprehensive character than before are now prepared, giving an accurate and fairly complete view of the progressive distribution of rainfall over the country. A weekly summary is published in the "Gazette of India," and rainfall charts drawn by hand are prepared weekly for the Viceroy and the Agricultural Department. Mr. Eliot has, however, suggested further changes of importance, including the adoption of a common type of rain-gauge (*i.e.*, Symons') throughout India, the supply and testing of all rain-gauges by the Meteorological Office before issue, more frequent inspections, the examination of all rainfall data for elimination of errors, and the annual publication of the rainfall data for the whole of India in a complete form for the use of engineers, irrigation officers, meteorologists of all nations, sanitary authorities, and generally

speaking, all persons interested in the subject. These reforms are now under the consideration of the Government.

A seasonal forecast, based partly on information of the snowfall in the mountain districts of Northern India during the previous cold weather months, and partly in the distribution of pressure in April and May, was prepared by Mr. Eliot, and published in the "Gazette of India" on the 13th of June. The main conclusions regarding the south-west monsoon of 1889 were as follows :—

(1.) The weather conditions in May over the land area, and the character of the cold weather snowfall were both favourable to the probable occurrence of an early and strong monsoon.

(2.) Conditions were unusually favourable for heavier rain than usual over the whole of North-East India, including Burma, Assam, Bengal, Behar, and the greater part of the North-Western Provinces.

(3.) The conditions in the Peninsula were, on the whole, favourable, and hence it was probable that the Bombay monsoon current would be at least of normal strength, and give normal rainfall over the Peninsula generally.

(4.) The conditions in Upper India, and more especially the Punjab, were more or less unfavourable ; and

(5.) So far as could be judged from the observation it was, on the whole, probable that Ganjam and the Northern Circars would receive at least normal rainfall.

A comparison of the statements of actual rainfall results with the forecast shows a very fair agreement. In fact, with the exception of Burma and Bengal, where the rainfall was normal or very slightly in defect, and in the North-West Provinces where it was considerably in excess, the forecast was fully verified.

The Bay of Bengal Storm-Warning Service was satisfactorily performed during the year, cautionary telegrams being despatched in good time in every case. Ample warning was also given from Simla to the west coast ports under the new arrangements for the Bombay Storm Signal Service. In the Bay of Bengal one of the most pressing needs in connexion with storm-warnings is the question of telegraphic communication with Port Blair, in the Andaman Islands. Not only are the largest and most intense cyclones generated in the centre of the Bay near the Andamans, but the proximity of the ports of Bassein, Moulmein, and Rangoon to this cradle of storms, and their distance from Calcutta from which point, nevertheless, they have to be warned, has induced

Mr. Eliot to record his strong opinion that it is desirable, if not absolutely necessary, for the warning of the Bengal and Madras coasts and almost essential to the proper and complete protection of the Burma coast that the cable should be laid. The Government have, however, not felt justified in sanctioning such large outlay, considering that such telegraphic communication was not urgently required at the moment for any other object than for meteorological purposes. Consequently this important measure is necessarily postponed for the present.

The general administration of the observatories and offices during the year 1889–90 was in the hands of the following officers:—

Names.	Office.	Province.
John Eliot, Esq., M.A., F.R. Met. Soc.	Meteorological Reporter to the Government of India.	Central Office.
W. L. Dallas, Esq.	First Assistant Meteorological Reporter to the Government of India.	Central Office.
C. Little, Esq., M.A. / J. H. Gilliland, Esq., B.A. (Offg.)	Second Assistant Meteorological Reporter to the Government of India.	Central Office.
Lala Hem Raj	Personal Assistant, the Meteorological Reporter to the Government of India.	Central Office.
A. Pedler, Esq., F.C.S. / C. Little, Esq., M.A. (Offg.)	Meteorological Reporter to the Government of Bengal.	Bengal and Assam.
J. R. Holt, Esq., C.S. (Offg.) / W. N. Boutflower, Esq., B.A. (Offg.) / S. A. Hill, Esq., B.Sc., F.R. Met. Soc.	Meteorological Reporter to the Government of the North-Western Provinces and Oudh.	North-Western Provinces, Oudh, Rajputana, and Central India (part).
W. L. Dallas, Esq.	Meteorological Reporter to the Government of the Punjab.	Punjab.
S. A. Hutchinson, Esq.	Meteorological Reporter for Western India.	Bombay, Berar, Rajputana, and Central India (part).
Miss Isis Pogson, F.R. Met. Soc.	Meteorological Reporter to the Government of Madras.	Madras, Mysore, Coorg, and Haidarabad.
Dr. G. C. Chesnaye / Dr. J. Richardson / Dr. J. G. Pilcher	Sanitary Commissioners, Central Provinces.	Central Provinces.
Dr. C. Little	Sanitary Commissioner, Berar	Berar.
Dr. D. Sinclair	Sanitary Commissioner, Burma	Burma.

Colaba and Madras Observatories.

The Government Observatory at Colaba is under the direction of Mr. Charles Chambers, F.R.S. It is devoted principally to the record and publication of facts and the prosecution of inquiry in terrestrial magnetism and meteorology, to astronomical observation for the purpose of time-keeping, and to the signalling of time for purposes of navigation. The results of the observations are published annually in the form of a quarto volume. The autographic instruments, which are maintained in continuous action, are the following :—1. Declination magnetograph. 2. Horizontal force magnetograph. 3. Vertical force magnetograph. 4. Barograph. 5. Thermograph, dry-bulb and wet-bulb. 6. Pluviograph. 7. Anemograph, direction and velocity.

The harbour clock and time-ball are worked by electric current from the Observatory, which is also charged with the custody of a store of Indian Government and Admiralty chronometers. Chronometers of merchant ships are also received for rating.

There is also an astronomical observatory at Madras, until lately under the direction of Mr. N. R. Pogson, C.I.E., who held the post of Government Astronomer from 1860 until his death on June 23rd, 1891. This observatory gives uniform time to the greater part of India for railway and other purposes, and its longitude* is the fixed point of the departure of the Trigonometrical Survey of India.

From the period of his taking charge up to 1885, Mr. Pogson discovered the following six minor planets between the orbits of Mars and Jupiter :—

Name.	Date of Discovery.	Period of Revolution. Y.	M.	D.
Asia -	- 1861, April 17 -	3	9	5
Freia -	- 1864, February 2 -	6	3	23
Sappho -	- 1864, May 3 -	3	5	22
Sylvia -	- 1866, May 16 -	6	6	0
Camilla	- 1868, November 17	6	6	7
Vera -	- 1885, February 6 -	5	4	24

Asia was so named on account of its being the first astronomical discovery made in that quarter of the globe. Freia was first discovered by Professor D'Arrest, at Copenhagen, 1862, October 21st,

* Its latest determination of longitude, as mentioned on page 213, is 80° 14′ 50·03″ E. of Greenwich.

but was lost owing to insufficient observations having been secured to render the calculation of its orbit definite. It was re-discovered independently at Madras. A bright telescopic comet was found at Madras, 1872, December 2nd. It remains a disputed point whether this was a re-discovery of the lost periodical comet of Biela, or whether the comet was a new one. Eight new variable and temporary stars were also discovered, particulars of which, including name, limits of magnitude, and period of variation, will be found at page 520 (note) of Vol. I. of the Madras "Manual of Administration."

The death of Mr. Pogson has now necessitated a reconsideration of the position, organisation, and equipment of the Madras Observatory, as well as the question of the utilisation of the large mass of observations awaiting publication. This matter is now under the consideration of Government. Mr. C. Michie Smith, F.R.A.S., F.R.S. (Edinb.), is in temporary charge of the Observatory.

XIV.

THE STATISTICAL SURVEY OF INDIA.

The last decade has witnessed the completion of an important undertaking in regard to our statistical knowledge of India, for the statistical survey commenced under the auspices of Lord Mayo, and placed under the supervision of Mr. (now Sir William Wilson) Hunter, was brought to a successful conclusion. It was the first systematic project of the sort, and at the same time, through local co-operation, it was exhaustive. A brief review of the previous efforts in the same direction, condensed mainly from Sir W. W. Hunter's account, as given in the preface to the "Imperial Gazetteer," is here desirable.

So far back as 1807 the Court of Directors of the East India Company wrote to their representatives in Bengal "that a "statistical survey of the country would be attended with much "utility, we therefore recommend proper steps to be taken for the "execution of the same.

The first attempt to make a statistical survey of Bengal dates from 1769, four years after the province came into the hands of the East India Company.

During the present century the Company issued a series of instructions for a systematic investigation into the resources of their dominions, the latest orders being three years before the administration of India passed from the Company to the Crown. During the ten years which followed the transfer of power, a new set of efforts was made, the chief being the inquiries in the Central Provinces, under the direction of Sir Richard Temple. At last, in 1867, the Government of India, under instructions from the Secretary of State, ordered an account to be drawn up for each of the twelve great provinces of India.

The provincial administrations struck out widely divergent lines for this scheme. It was just as if (Mr. Hunter remarked) a command had been issued from some central power for a statistical survey of all Europe, and each nation set about its execution on a

separate plan. It became apparent that vast sums of money would be expended, while considerable uncertainty existed as to the results. In the meantime, the Royal Asiatic Society pointed out that when the local accounts came to be digested, there would be no basis for comparative statistics, and much "of the original work "would have to be gone over again *de novo*." This opinion was shared by the Governor-General in Council, and Mr. Hunter was directed to visit the various local governments and "submit a "comprehensive scheme for utilizing the information already col- "lected, for prescribing the principles, and for the consolidation "into one work of the whole of the materials that may be "available." The previous efforts were reviewed by the Viceroy in a resolution dated 8th September 1871, the weak point being shown to be the absence of a central organization, and the want of a settled plan.

Mr. Hunter's scheme was submitted to the Governor-General in Council in 1869,* and received the approval of the Government, who further secured for the execution of the design the supervision of the designer. Mr. Hunter, who had been attached to the Bengal Secretariat, and acted as Under Secretary to the Supreme Government, was appointed Director-General of Statistics with a view to the construction and execution of a Statistical Survey of India. The object of the undertaking was to provide a storehouse of statistical information for the controlling body, for administrators in India and for the public, and the operations were to extend over ten separate Governments, which, with their Feudatory States administer a territory 1,500,000 square miles, and govern a population then estimated at 200,000,000 souls, but since found to be at least 255,000,000. Roughly speaking, this area and population may be likened to those of all Europe, excepting Russia. With the view of uniformity in the supply of materials, Mr. Hunter drew up six series of leading questions, illustrating the topographical, ethnical, agricultural, industrial, administrative, and medical aspects of an Indian district. These served as a basis for the statistical survey throughout India. In this way the unpaid co-operation of the administrative staff throughout the 240 districts of India was enlisted, the best local knowledge was brought to

* Plan for a Statistical Survey and an Imperial Gazetteer of India. Printed at the Home Secretariat Press, Calcutta, 144 pp., folio, 1870.

bear, while in each province a paid editor was answerable for the completion of the provincial account; the general supervision of the undertaking resting with Mr. Hunter, as Director-General of Statistics to the Government of India.

The district forms the administrative unit in India, and the province the administrative whole. The statistical survey groups all the district materials into fifteen provincial accounts or gazetteers.

The Feudatory States and Chiefdoms, exceeding 300 in number, with 50,000,000 of people, were from the first placed outside of the scope of the statistical survey, as it was thought the native princes would have misunderstood any attempt at systematic investigations. Steps were taken, however, to collect some of the information already existing with regard to Native States; but no regular survey was attempted, and a census of the territories did not exist, therefore, as a whole, the results as to feudatory India are far inferior to the rest. This was due to the political exigencies of the case, which were of course beyond the control of the Director-General of Statistics.

The reduction of the numerous volumes of the Statistical Survey to a practicable size for general reference was the last stage of the undertaking, the results of this being the nine volumes of the "Imperial Gazetteer." A list of towns, rivers, mountains, historic sites, religious resorts, commercial fairs, harbours, or other places of importance, were compiled from returns contributed by the provincial editors and district officers. Eleven thousand names were thus arranged in alphabetical order and printed in a folio volume, and after that they had been checked by the local governments, about 8,000 places were selected for inclusion in the "Imperial Gazetteer." A few model articles were also drawn up for the guidance of the contributors, showing paragraph by paragraph the method of treatment. In this way the preparation of the work was arranged for.

The bases of the statistics in the Gazetteer were the figures of the census of 1872, but in certain provinces reliance had to be placed on enumerations taken in 1867 to 1871, while the administrative and trade statistics were brought up to 1875 and even as far as 1880.

In its historical aspect, Mr. Hunter considered that the work was deficient, and the following extract from his preface to the

Gazetteer throws an interesting light on what was requisite and what was actually achieved in this direction :—

"If the history of India is ever to be anything more than a record of conquest and crime, it must be sought for amongst the people themselves. Valuable historical materials had been collected for the Statistical Survey, and in 1877 the Secretary of State for India decided that a wider scope should be allowed me for their use in the 'Imperial Gazetteer.' I have done my best to give effect to that view, and it will be seen that for the first time in these volumes that every Indian district has its own history. The true territorial unit of Indian history is, indeed, much smaller than the British district. For example, he who would study the history of Oudh must search for it in the *pargana* or parish; in other parts of India the *zamindar* or estate is the historical unit; in others the chiefship, while in a few the rural districts were mere appendages to the great cities. Had it been permitted me to subject the rural annals of India to systematic inquiry, as I wished, a rich harvest would have been gathered in."

The latitudes and longitudes of the different localities were supplied by the department of the Surveyor-General of India, while areas, distances, and similar data were furnished from the same source. The statistics were not strictly comparable and not thoroughly accurate, but India was then and is even now in its infancy as regards statistical data. When the survey was begun no one knew exactly the population of a single province of India, or of a single district of Bengal. In the latter province the census of 1872 suddenly disclosed the presence of 22,000,000 of British subjects, whose existence had never previously been suspected. The population of Bengal and Assam up to that time reckoned at 40,000,000 was ascertained in 1872 to amount to 67,750,000 of souls.

A uniform system of spelling of Indian proper names had long been discussed, and was one of the essential preliminaries of the "Imperial Gazetteer." In the old gazetteers the same word appeared under many forms, one town being spelt in eleven different ways, not one of which was correct, and in order to be sure of finding a place, a student had to look it up under every possible disguise. A knowledge of the vernacular languages of India and of Sanskrit is necessary to enable one to spell the native names correctly in the native alphabets, and a scientific system of transliteration into the English characters was a further essential.*

* There is a strong plea for the correct and uniform orthography of proper names in Mr. S. E. Peal's "Note on the Origin and Orthography of River Names in Further India" (*see* Proceedings of the Royal Geographical Society, p. 90 of 1889). Major Raverty too is a doughty champion in the same cause, *see* his "Notes on Afghanistan," *passim*. Dr. Burgess has recently contributed a suggestive article on the same subject to the Royal Scottish Geographical Society's Magazine. *See also* "Report on Uniform System for spelling Foreign Geographical Names" (Navy Department), Washington, 1891.

Round this question there had raged a battle for over a hundred years. Sir William Jones, the first scientific investigator of the subject, showed that there were practically two systems of exhibiting Asiatic words in English, the "scientific" and that subsequently called "phonetic," the first being based on "scrupulously rendering, "letter for letter, without any particular care to preserve the "pronunciation," while the second proposed "to regard chiefly the "pronunciation of the words intended to be expressed."

In the early years of British rule, the Indian proper names were written down simply by ear, without any attempt at correctness, and Mr. Markham, in his chapter on the orthography of Indian names, in the "Memoir," gives some amusing instances of this, such as "Sir Roger Dowler" for Siráju'd-daulah; Crotchy for Karáchi (Kurrachee), and "Isle of bats" for Allahabad. But when the British officers came to study the eastern tongues a reform was soon initiated. Major Davy, a Persian scholar, was a strong supporter of a phonetic system, and his plan was adopted in the "Institutes of "Timur," which was published in 1784. Major Davy's contemporary, Mr. Halhed, on the other hand, advocated and adopted a scientific system in his code of Hindu law, compiled under the orders of Warren Hastings in 1775.

Sir William Jones, not satisfied with Mr. Halhed's system, devised the alphabet which bears his name. He provided for all the sounds used in Sanscrit, Arabic, and Persian, by the adoption of the Roman or Italian sounds of vowels. Sir William's modification of the scientific method was called, after himself, the Jonesian system. Other champions arose; Dr. John Gilchrist and Mr. Henry T. Prinsep maintaining the superiority of the phonetic system, while Sir Charles Trevelyan and numerous missionaries upheld the scientific or Jonesian system. The contest was transferred, in 1858, to the columns of the "Times" and other journals, and Mr. Monier Williams, Professor Garratt, Mr. Eastwick, Mr. Marshman, Colonel Meadows Taylor, and the Rev. J. Barton, supported one view or the other, but with no decisive result.

In 1868 a proposal was made by Mr. Burgess through the Bombay Geographical Society for the preparation of a vernacular and English index of Indian geographical names.* Sir William Hunter was instructed to prepare a system with a view to uniformity in the

* English indexes of all villages in the Bombay and Bengal postal circles have since been carried out at the instigation and largely under the direction of H. E. M. James, Bo.C.S.

spelling of these names, and his plan was eventually adopted for the gazetteer and for general use. No practicable scheme could also combine absolute precision. The Roman alphabet has, for instance, but one letter for the consonant *n*; the Sanscrit has four letters for it in its various modifications as a dental, lingual, palatal, and guttural. Again, the Indian alphabet has two separate letters for *d*, two for *t*, and three for *s* and *sh*. Indian names could, therefore, be represented only in an approximate manner in our tongue without the manufacture of a new Roman alphabet, with additional letters, by means of accents over the vowels, dots under the consonants, italics, or the like. In the system laid down by Sir William Hunter and adopted by the Government of India, dotted consonants are rejected, as few accents as possible over the vowels are used, and, generally speaking, everything is avoided which would give the alphabet an un-English look. Moreover, names of important places which had attained a historical or literary fixity of spelling were retained in their popular form, such as Calcutta, Madras, and Bombay. The method did not attempt to reproduce such fine distinctions as the four Sanscrit *n*'s or such consonants as the dental and lingual *t* and *d*. But a uniform value was assigned to each vowel, namely, *a* and *u* as in *rural*; *e* as in *grey*, *méchant*; and *i* and *o* as in *police*. The accented *á*, *í*, and *ú* represented the long forms of the same vowels in Sanscrit, or the sounds in the English *far*, *pier*, and *lure*.

The process of adoption of the uniform spelling of the geographical names in all Indian Government publications has necessarily been of slow growth. But the existence of a standard work of reference like Sir William Hunter's "Imperial Gazetteer" has been a great step towards uniformity of spelling, and all new maps issued by the Surveyor-General's department follow the prescribed spelling, so in process of time we may not despair of seeing absolute uniformity attained wherever India is mentioned.

The second edition of the "Imperial Gazetteer," produced in 1885, took as its starting point the census of 1881, which was also the first complete and fairly synchronous census of India. Its administrative statistics refer chiefly to the years 1882–84, but in certain of the larger questions dealt with the facts were brought down to 1885.

XV.

INDIAN ARCHÆOLOGICAL SURVEYS.

The archæological remains of India, apart from their artistic interest, are invaluable to the student of history, but it is only within comparatively recent years that their conservation has been undertaken by Government. This is regrettable, for, as has been truly remarked, delay in such matters is irreparable. "Paintings fade from walls, sculptured edifices are destroyed by the vigorous growth of trees and by ruthless modern builders in want of material, coins and inscriptions are mislaid or effaced, and all the works of man suffer more or less under the hand of time."* The earlier notices of Indian antiquities were those of passing travellers, in whose time the knowledge of the languages, literature, and history of the country was too scanty and undeveloped to enable them to appreciate the true significance of the monuments and ruins which they beheld. It was not till the foundation of the Asiatic Society at Calcutta in 1784, under the auspices of Sir William Jones, that any real attempt was made to critically examine Indian archæological remains. Since then the proceedings and journal of that body and of kindred societies at Bombay and Madras have

* Markham's Memoir on the Indian Surveys, p. 236. I must remark, however, that the practice of carting away and utilizing the fragments of old temples of high antiquarian interest for ordinary modern building purposes has by no means been confined to native builders. So far back as 1784 Mr. Charles Grant, a resident at Malda, wrote as follows:—"I imagine a number of stones sufficient for the pavement of the New Church, may be " collected from the ruins of Gour . . . all the remains of Gour are unquestionably " the property of Government, which we may dispose of at pleasure as was the custom of " the Soubahdars." (Historical and Ecclesiastical Sketches of Bengal. Calcutta, 1831, p. 188.) Fergusson in his "Indian Architecture" makes mention of an inscribed Asoka pillar converted by some utilitarian officer into a roller for the station roads at Allahabad. (*See* page 53.) Again, in 1885, a French archæologist drew attention in the columns of the "Temps" to a gross act of vandalism, whereby no fewer than 40,000 cubic feet of stone, the ruins of decayed temples and palaces forming the ancient city of Chandravati, the early capital of Gujrat, were carted away by railway contractors. This is corroborated in Mr. H. Cousens' progress reports on his tour in 1889-90 in North Gujrat. The general subject was brought to the notice of the Government of India, Home Department (June 10, 1886), and a Circular (No. 4, P.W. of September 8, 1886) was issued for the better protection of remains from destruction by railway contractors, &c. &c.

become the repository of a mass of information on the subject. The first archæologists were scholars of the type of Sir William Jones, Charles Wilkins, Henry Colebrooke, Francis Gladwin, William Chambers, and Colin Mackenzie*, followed by F. Buchanan-Hamilton and Horace Wilson; and the detailed investigations of these accomplished savants are admirably told in the pages of Mr. Markham's "Memoir." Their labours were preceded and supplemented by a most meritorious collection in six large folio volumes of aqua-tint drawings (1795–1807) by the artists, Thomas and William Daniell and James Wales, of the principal monuments and edifices of Hindostan.

The next conspicuous name in the history of Indian archæological research is that of James Prinsep, who became Secretary of the Bengal Asiatic Society in 1832, and to whose industry and genius we owe the decipherment of the edicts of the great Buddhist King Asoka. Prinsep was also one of the first to discover positive dates in early Indian history. His labours were seconded by Mill, Masson, B. H. Hodgson, Burt, Kittoe, Postans, and others of minor fame, while his zeal and scholarship have been emulated by his contemporaries and successors, the more distinguished of whom have been Cunningham and Maisey in Upper India; Meadows Taylor, and Wilson in Bombay; Dr. B. G. Babington and Sir Walter Elliot in Madras; and Dr. Burgess for Western and Southern India. But it is to James Fergusson that the elucidation of Indian architecture and art is mainly due, a task for which his genius and taste as well as his extensive journeys and researches over the whole expanse of India had admirably qualified him. Apart from a number of papers in the transactions of learned societies, he was the author of an important work, entitled "History of Architecture," in which Indian architecture is classified and expounded. The following are the principal heads:—1. *Prehistoric* Remains, such as cairns, cromlechs, and other cognate remains of unknown age, constructed by an unknown people, and scattered widely in different parts of India. 2. *Buddhist* Remains.—A wide interval separates the cairns and cromlechs from the Buddhist remains, for the Aryans who composed the Vedic literature built nothing that

* Dr. Burgess, in a learned paper on "Archæological Research in India," read by him before the Oriental Congress at Stockholm, in 1889, says that Mackenzie visited nearly every place of interest south of the Krishna river, and prepared over 2,000 measured drawings of antiquities, carefully laid down to scale, besides facsimiles of 100 inscriptions, with copies of about 8,000 others in 77 volumes. Of the drawings, the only portions published are those from Amravati, and in "Tree and Serpent Worship."

has endured to our time. For five centuries from 250 B.C. nearly all monuments in India are Buddhist and Jaina, consisting of rock inscriptions, *lats* or pillars with inscriptions, topes or stupas, rock-hewn temples, and *viharas* or monasteries, the most important being the Sanchi tope in Bhopal in Central India, described by Cunningham and Fergusson, and the Amravati tope near the mouth of the Kistna, also described in the "Tree and Serpent Worship," and by Dr. Burgess. 3. *Dravidian* Architecture.—This style extends over all India south of the River Krishna, and the temples are of vast extent and magnificent design. They are recognisable by their pyramidal form, distinction of storeys, and separation into compartments by pilasters. 4. *Bengali* Architecture.—These temples, on the other hand, have no trace of division into storeys, no pilasters, and a curvilinear outline with a polygonal base. The style first appears in the sixth or seventh century, and the best examples are found at Bhavaneswar, in Orissa, and round the temple of Jagannath, and thence across India as far as Dharwar. 5. The *Chalukya* style of Architecture prevails in Gujarat, Kanara, Mysore, and Rajputana. The Hallabid temple, one of its finest examples, was built at the same time as Lincoln and Salisbury cathedrals, and is considered by Mr. Fergusson to be among the most marvellous exhibitions of patient human labour [illegible] world has ever produced.* 6. The *Jaina* temples are numerous and elaborate, and have been described by Mr. Burgess. The most noticeable examples are at Satrunjaya, Girnar, Mount Abu, and Sadri, and they are found along the western Deccan as far as Belgaum, as well as in Bengal and the Central Provinces. 7. Lastly, the *Muhammadan* or *Saracenic* Architecture, in the form of beautiful mosques and tombs, is scattered over nearly all parts of India except the extreme south. They range over distant periods, and combine the general features of Muhammadan with the impress in details of local native art. Striking and beautiful examples are to be seen at Jaunpur, Ahmadabad, Bijapur, Delhi, and many other spots. The tomb of Akbar and the Taj Mahal, which represent the Mogul architecture, are even more widely known, and have been thoroughly examined.

In connexion with this subject, it may be useful to mention that Mr. Burgess classifies the buildings of Western India as follows :—

1. Buddhist remains.
2. Brahmanical and Jaina Cave Temples

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* *See* History of Architecture, II., p. 609.

3. Rude and Sculptured monuments, &c.
4. Temples, &c. in the Dravidian or Southern style.
5. Temples in the Chalukya, Rajput or Northern style.
6. Mediæval remains.
7. Modern Hindu remains.
8. Musalman remains.

The following extract from his notes on the peculiarities of the various eras and styles, though somewhat lengthy, is interesting, and will serve to illustrate the above classification.

"The earliest architectural remains are those of the Buddhists, ranging from about 250 B.C. to the seventh or eighth century A.D. chiefly in the form of rock-cut temples and monasteries. The *dahgoba*—large cylindrical structures with a domed top surmounted by a capital—and the arched roofs of the *Chaitya* or temple-caves are characteristic marks of Buddhist caves, so also is the prevalence of the Chaitya window or horse-shoe-shaped arch as an ornament; though in a modified form, this is also found in early Brahmanical buildings and caves. The *viharas* or monasteries have usually cells round them often with stone benches or beds inside.

"The style and subjects of sculpture, where there is any, will also generally indicate whether a cave is Buddhist or Brahmanical, and it should be so described. In Sindh there are, at least, two Buddhist *topes*, huge dahgobas, usually of brick; and there are possibly a few ruined temples in the northern zillâhs of the Presidency that may have been Buddhist; all such remains should be carefully inquired for and reported on.

"*Caves.*—Jaina caves are sometimes so like the later Buddhist caves at Ajanṭâ that they are difficult to distinguish by those not versed in their peculiarities. Those at Dhârâsiṅva are of this character; generally the nudity of the images, their snakes, and ringlets at once mark them.

"Brahmanical caves are not so numerous as the Buddhist ones, but they are quite as interesting, and search might bring more of them to light. They range probably from the 5th to the 8th century A.D. Instances of S'aiva caves are to be seen at Elephanta and Joges'wari near Bombay, at Elurâ, and at Aihole and Bâdâmi in Kalâdgi, and two fine Vaishṇava ones at the last-named place. Brahmanical caves, so far as yet known, consist of halls with a single cell or shrine, and occasionally, as at Elephanta, with one or two small cells for utensils, &c., but without rooms for monks along their sides. The sect to which a cave belonged is determined by the sculptures; the Linga, Gaṇapati, S'iva, Bhairava, Arddhanâri, Râvaṇa, Bhringi, Pârvatî, Mahisâsurî, &c., figuring prominently in S'aiva, and Vishṇu, Varâha, Nṛisiṅha, Virabhadra, Garuḍa, &c., in Vaishṇava caves.

"*Monuments.*—In Belgaum, Kalâdgi, and elsewhere there are scattered groups of *dolmens*, formed of large rough slabs set on edge with a huge capstone laid over them; there are, perhaps, also to be found barrows or mounds, as in Shorapur, marking ancient places of sepulture. So [illegible] is known of them from competent investigators, that it is desirable to know more about their numbers and distribution over the country; of the local traditions respecting their origin; of the different names, such as Kodi Kols, &c., by which they are known; and that those that have escaped destruction at the hands of vulgar curiosity, or the hammers of Wadâris, should be carefully protected. Similar remains should be looked for in all districts. One dolmen was recently discovered in Northern Gujarat.

"Upright monumental stones or *menhirs* are less common than the table-stone or dolmen, but instances of their existence should be noted.

"Pâliyas and satî stones in Gujarat and Kachh and the pâdukas or footprints of Sadhus are too numerous to register; but there are many varieties of each, and instances of the oldest and finest in each class should be noted. On the older pâliyas, too, are sculptured the style of dress and warlike accoutrements of olden times—chain armour, horses in mail, bows and arrows, swords of various sorts, shields, javelins, &c., and not unfrequently the names of reigning princes, &c., with dates. Copies of some of these would be very useful. For example, if the pâliya of Lâkhâ Phulâni exists at Adkoṭ and can be read, the date and era on it would settle an important point in the chronology of Kachh and Gujarat. Such as are likely to be of interest should be noted.

"*Styles.*—The Draviḍian style of Hindu architecture prevails chiefly in the southern districts of the Presidency and of the Haidarabad territory, and is characterized by its massiveness in walls, pillars, &c.; the principal architectural lines in the roofs and spires are horizontal, making the latter resemble storeyed pyramids; and the vertical breaks in the wall line are of but slight projection, sometimes set off with slender pilasters with or without sculptures between. In the earlier remains of this style the pillars are generally very thick and square or octagon, with heavy bracket capitals; in the latter they are sometimes round, and generally remarkable for the number of horizontal members on the shafts and bases; the capitals (except the abaci) are circular with bracket sur-capitals. The remains in this style belong to the period between the 5th and early part of the 13th century. As examples of it may be mentioned the Kailâs temple at Elurâ; the Seven Pagodas near Madras, and all the temples in the first report of the *Archæological Survey of Western India*—only one at Paṭṭadkal, represented in Plate XLVI., has a spire in the Châlukya style.

"The Châlukya style ranges from the 9th to the middle of the 14th century, and is characterized generally by more elaborateness of ornament, by balconies and roofings supported by richly-carved brackets, by the outer faces of the walls of shrines being broken up into a series of projecting corners with equal faces, and by pillars square in section with a projecting face on each side, or like a square pillar with a slightly narrower but very thin pilaster added to each side. These latter, however, while the typical section was retained, were liable to great modification from the great amount of sculpture often lavished on them. The spires are proportionately loftier than those of the southern style, with a couple or more of successive projections on each side: the faces and lines of projection are vertical at first, but higher up they fall inwards with a gentle curve towards the summit, which is crowned by a *kalas* or finial varying in form and size with the locality and age of the building. The walls are often elaborately carved with belts of figures, and the stones are carefully fitted and clamped inside, but without mortar. Some of the finest examples of this style are to be found in the gates at Jhinjuwâḍâ, the gates and Hirâ Temple at Dabhoi, the temple at Mudhera, and Rudra Mâla at Siddhpur in Gujarat, and in the Jaina Temples at Mount Abu, in the small temple at Amaranâth near Kâlyâṇ, and in some shrines at Paṭṭadkal and Aihoḷe in Kalâdgi.

"To these two seems to have succeeded what may be called the *mediæval* style combining some of the features of each, and covering the period from about 1150 to 1600 A.D. To it belong most of the Jain temples and the later Hindu temples in Gujarat, and those temples usually described as 'Hemâdpanti' in Khandesh, Berar, and the Haidarabad territory, dating from about the 12th to the middle of the 14th

century. These temples and the *bauris* or wells and reservoirs of the same style and age have been very imperfectly examined; and as they often present features of considerable interest, all such examples, both of temples and reservoirs, should be carefully noted.

"In the modern Hindu styles from the 17th century there is considerable variety; the Muhammadan curved arch is often introduced; forms derived from the Dravidian have travelled northwards, and plaster and mortar take the place of sculpture and careful jointing. In some cases, more frequently in civil than sacred edifices, however, very beautiful wood-carving is introduced, such as is to be seen in many parts of Gujarat: the best examples of this might be noted.

"On the styles of the Muhammadan buildings in the Presidency and neighbouring States, little need be said; the cusped arch and the dome are their common characteristics, but the style of the Ahmadabad and that of the Bijápur buildings present points of marked difference. A description should be given of the more notable Muhammadan buildings at such places as they exist, with notes of the form, size, and any special peculiarities, whether of style or ornamentation.

"Perforated stone-work occurs in old Hindu buildings; but specimens remarkable for the variety of beautiful design are chiefly to be found in the Muhammadan works of the 15th and following centuries at Ahmadabad and Aurangabad, and, doubtless, in other scattered localities where Muhammadans of wealth have at any time been settled."

Such are the principal epochs and styles into which Indian architecture has been grouped by Mr. Fergusson and Mr. Burgess, and which the patient researches of individual observers have done so much to illustrate. For a record of the latter we must refer our readers to the pages of Mr. Markham's Memoir, where copious and detailed references to the published accounts of these investigations up to 1875 are given.*

During the last fifteen years the work of General Alexander Cunningham and Dr. James Burgess deserves most prominent mention. The former was an old friend of James Prinsep, and inspired by a like antiquarian taste and zeal he sketched out a plan (published in the Journal of the Asiatic Society of Bengal, XVII., Pt. I., p. 535) for an Indian Archæological Survey as far back as 1848. Fourteen years after, Lord Canning gave his sanction to a scheme, the object of which was the preservation of the ancient monuments of Upper India, the rendering them easy of access, the acquisition of correct copies of inscriptions and pieces of sculpture, and the facilitating the

* A valuable means of reference to the archæological and scientific labours of Indian savants is furnished by the "Centenary Review of the Asiatic Society of Bengal" from 1784 to 1883. The history of the society is written by the late Dr. Rajendrala Mitra, C.I.E.; the archæology, history, and literature by Dr. A. F. R. Hoernle; and the natural science by Babu P. N. Bose. The work was published at Calcutta (Thacker, Spink, & Co.) in 1885.

studies of antiquaries and historians†. General Cunningham was placed in charge of the operations. His first investigations lay in the country adjoining the course of the Ganges, and forming the ancient kingdom of Magadha, the centre of Indian Buddhism during its period of ascendency. During this early epoch, two Chinese pilgrims, Fa Hian (A.D. 399–414) and Hwen Thsang (A.D. 629–45) visited India, and the localities, cities, and monuments described by them form important historical and topographic landmarks, which it has been the special aim of modern students and comparative geographers to identify. General Cunningham has observed that as Pliny follows the route of Alexander, so an inquirer into Indian archæology should tread in the footsteps of the two Chinese pilgrims, Fa Hian and Hwen Thsang. Dr. Burgess, too, remarks that there was no Indian Herodotus, Strabo, or Pausanias, and that we learn more of the history and ancient geography of India from these two Chinese travellers than from the whole vast field of Sanskrit literature.

During his first season, 1861-62, General Cunningham identified a number of ruins of Buddhist structures, especially at Buddha Gaya, which, owing to the number and importance of its remains, has since at intervals occupied the attention of himself and his assistants. The following season was spent mainly at Kalsi, where an impression of King Asoka's inscription, containing the names of five Grecian kings was taken, and at Mathura and at Delhi. The Punjab was the scene of General Cunningham's explorations in 1863-64, during which he made good progress in identifying the cities and peoples described in the expedition of Alexander the Great from the west bank of the Indus downwards, examining every site mentioned either by the Greek writers or by Hwen Thsang, and giving detailed accounts of Taxila, Manikyala, and of the scene of Alexander's great battle with Porus on the Jehlam. The work of the following season lay among the ancient cities between the

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* Lord Canning's minute, dated 22nd January 1862, said, "It will not be to our "credit, as an enlightened ruling power, if we continue to allow such fields of "investigation as the remains of the old Buddhist capital of Bihar, the vast ruins of "Kanauj, the plains round Delhi, studded with ruins more thickly than even the "Campagna of Rome, and many others, to remain without more examination than "they have hitherto received. Everything that has hitherto been done in this way "has been done by private persons, imperfectly, and without system. It is impossible "not to feel that there are European Governments, which, if they had held our rule "in India, would not have allowed this to be said."

Jumna and Narmada, and an interesting account of the Dhamnar caves was drawn up. General Cunningham had now examined and described the ruins and inscriptions in nine of the ancient kingdoms of Hindostan.* But in 1866 the appointment of archæological surveyor was abolished by Lord Lawrence, and for a time General Cunningham's useful investigations were suspended, while he himself returned to England. The interval was, however, profitably employed by the General in the preparation of an important and learned work on the ancient geography of India, in which the routes of Alexander and Hwen Thsang were traced and numerous historical sites identified.

In 1867 public interest in the conservation of ancient monuments, and the collecting of photographs thereof, again revived, and the Government of India issued a circular to the local governments, expressing their sense of the importance of taking steps in that direction, and calling for lists of monumental remains and works of art in the various provinces. The Government were prepared to assist in the purchase of private photographs, and to expend a sum of Rs. 52,000 a year for parties in the four largest provinces to make models, plans, photographs, and descriptions of the more important buildings†. The Science and Art Department added the weight of their recommendation in the same direction, and even offered to share expenses, laying stress at the same time on the expediency of making casts as well as plans and photographs of the finest monuments.

The local governments placed the work under the heads of the Schools of Art; and in Bengal a party was sent to Orissa and took casts at Bhavaneswar temples, and, during the second season, at Khandagiri caves. The superintendent of the Bombay School of Art went to Amaranath, near Kalyan, in the Konkan, and took a series of casts and also made a number of excellent drawings, afterwards published in the "Indian Antiquary," III., 316–320. In connexion with this scheme also, Capt. H. H. Cole was sent to Sanchi, and made casts of the eastern gateway there, of which copies are to be seen in the South Kensington, Edinburgh, and Dublin National Museums.

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* General Cunningham's four reports for the years 1862–65, were re-published in two volumes at Simla in 1871.

† Government of India, Home Department Resolution, No. 14–931 of 24th February 1868.

The general interest thus shown was gratifying, but the importance of conducting the researches in a more systematic manner, and on some definite plan became apparent. A suggestive and weighty despatch was addressed by the Duke of Argyll, then Secretary of State, to the Indian Government*, which led to a resolution being passed to form a central establishment to collect the results of former investigations, to train a school of archæologists, and to direct and systematise local and private efforts. This central establishment appears, however, not to have been carried into effect. The direction of the department charged with the work of surveying was offered to General Cunningham, whose invaluable services were thus again fortunately secured to India.

The next year (1871) saw General Cunningham with his two assistants, Messrs. J. D. Beglar and A. C. Carlleyle, beginning work by a survey of the two great capitals of the Mogul Empire, Delhi and Agra. In 1872 Mr. Carlleyle was deputed to Rajputana, Mr. Beglar to Bundelkhand, while General Cunningham visited Mathura, Buddha Gaya, Gaur, and other sites. The explorations at Delhi, Agra, and in the Doab are described in Vol. III. of the series of reports, and the same work contains General Cunningham's plan for the execution of the survey. The fourth volume consists of the detailed reports on Delhi by Mr. Beglar, and on Agra by Mr. Carlleyle, while the fifth deals with General Cunningham's tour in the Punjab in 1872–73, during which an extensive collection was made of Buddhist sculptures of the Indo-Scythian period.

In 1872–73 Mr. Beglar made an examination of the old course of the Son River, which appears to have run parallel to the Ganges for many miles, Pataliputra or Palibothra (Patna), the capital of the Gangetic Provinces, being probably situated in the long narrow strip between the two rivers. Mr. Beglar thinks, however, that the actual site of ancient Pataliputra is now under the waters of the Ganges, which, like the Son, shifted its course some little time before the Muhammadan conquest. It is difficult otherwise to account for the total disappearance of the fort, palaces, towers, and other buildings. The modern city of Patna dates only from the time of Shir Shah, 1541 A.D. A visit was also paid by

* India, Despatch No. 4 (Public), dated 11th January 1870. *See also* Government of India Resolution, No. 649–650 of 2nd February 1871, and Proceedings of Sub-Committee, Public Service Commission, Scientific Departments, pp. 27 ff.

Mr. Beglar to the ancient temple of Buddha Gaya,* to Barakar, Telkupi, and other localities of archæological interest in the ancient kingdom of Magadha.†

In 1873–74 and 1874–75 General Cunningham traversed nearly the whole of the western half of the Central Provinces,‡ his first attention being directed to the magnificent stupa of Bharhut,§ half-way between Allahabad and Jabalpur. Proceeding through Bilhari, a town formerly of considerable importance, as shown by its ruined temples and fine tanks, and Rupnath, where lies one of the short rock-cut inscriptions of Asoka (*see* p. 369), General Cunningham made some researches at the great fortress of Singorgarh, a place famous for the unprovoked attack made by the Muhammadan Governor of Kara on the brave Hindu Princess Durgavati, whose great wealth had excited the cupidity of her neighbours, and for the great battle which ensued (1563 A.D.), resulting in the death and defeat of Durgavati. General Cunningham also inspected the curious Buddhist caves at Bhandak, near the Warda River, and the fine group of temples at Markandi on the Wain Ganga River. He also treats in his report of the country of the Gonds, called Gondwana by the Muhammadans, which occupies the southern part of the region traversed during the two seasons. The true Gond country, however, is of larger extent, and consists of the long table-land which gives rise to the Tapti, the Wardha, the Wain Ganga, and the Narmada. In ancient times the region would appear to have been called Gauda or Gaur, and General Cunningham identifies the people with the Phyllitæ (leaf-clad) Gondali of Ptolemy. The tenth volume of the Archæological Survey of India Reports, issued in 1880, treats of two tours by General Cunningham in Bundelkhand and Malwa in 1874–75 and 1876–77, the chief points of interest in which were the discovery of several monolith capitals

* A complete monograph on Buddha Gaya by the late Dr. Rajendrala Mitra, C.I.E., was published in 1878. This work was reviewed by Dr. Bhagwanlal Indraji and the editor, in the Indian Antiquary for 1880, pp. 113 f. and 142 f., and in Fergusson's Archæology in India (1884), pp. 84, &c. There are short accounts of Dr. Mitra's antiquarian labours in the "Times" of July 30th and "Athenæum" of August 1st, 1891.

† Mr. Beglar's Report, with a preface by General Cunningham, and illustrated by plans and illustrations, forms Vol. VIII. of the Archæological Survey of India Reports.

‡ Vol. IX. of the Archæological Survey of India Reports.

§ Described by General Cunningham in a separate work published by order of the Secretary of State for India in 1879.

and other remains of the time of Asoka and his successors, and of numerous specimens of the architecture of the Gupta period. The General also visited Khajuraho, in the small native State of Chatarpur, for the purpose of examining the Ghantai temple which, on the occasion of his previous inspection, he had considered to be a Buddhist structure, but which Mr. F. C. Black, C.E., after careful examination, pronounced to be a Jaina temple.* This opinion was accepted by General Cunningham on his re-examination of the building and its surroundings. Fresh visits were also paid to the great Buddhist stupa at Sanchi, and a good number of pillars which formerly supported the circular colonnade were dug up, besides 21 new inscriptions. An interesting square temple at Deogarh, apparently of 7th century date, with all the characteristics of the style of the Gupta period, and first brought to notice by Captain Charles Strahan† in the course of his survey operations, was also carefully described.

During the next year General Cunningham examined many curious remains of Hindu architecture and sculpture of all ages. Of the old Buddhist times there are the ancient mounds of Panch Pahari, or the "Five Hills," close to Patna, from whence Akbar viewed the city when he was besieging Daud Shah, the last king of Bengal. Of the same age are the old temples and stupas of Sravasti and Tandwa. Of the Indo-Scythian period there is a very curious group of sculpture from Tusaran Bihar, near Allahabad. Two inscribed stone pillars at Bilsar in the Doab belong to the Gupta age, while the period of Muhammadan rule was well represented by the grand old masjids at Budaun of the time of Iltitmish, A.D. 1202-09, by the magnificent masjids at Jaunpur, built by the Sharqi kings in the 15th century A.D.,‡ and also by the tomb of Sher Shah at Sasseram, possessing the largest dome in Northern India, and picturesquely built after the Hindu fashion in the middle of a sheet of water. Two identifications made by General Cunningham during the tour were of great historical interest in regard to the early career of Buddha. One was the famous Uruvilwa forest of *vilwa* or bel trees, whither Sakya Sinha

* *See* Mr. Black's paper in the Journal of the Asiatic Society of Bengal, Vol. XLVIII., Part I., 1879.

† Report on the Topographical Surveys of India. 1870-71, Appendix A., Gwalior and Central India.

‡ Subsequently visited and described by Dr. Führer and Mr. Ed. Smith (*see* page 339).

retired for contemplation, and where he finally attained to Buddhahood. The place is now represented by the small hamlet of Urel, which is a simple contraction of the Pali name Uruwel, the bel forest, and the whole neighbourhood abounds with bel trees. The other identification is that of Nawal, near Bangarmau, as the Nava-deva-kula of Hwen Thsang. Another visit was also paid by the General to Buddha Gaya for the purpose of examining the surrounding country and making a survey of the ancient sites, and to the vicinity of Patna for the purpose of identifying various references to Pataliputra made by Fa Hian, Hwen Thsang, Arrian, and other old authorities.

The twelfth volume of the series presents us with the results of tours in 1874–75 and 1875–76 in the Central Doab and Gorakhpur by Mr. A. C. L. Carlleyle, First Assistant, Archæological Survey. In the Doab he examined the great mound of Indor Khera, eight miles to the S.S.W. of Anupshahr on the Ganges, where he found a copper plate inscription of the great King Skandagupta, dated in the year 146 of the Gupta era. He also discovered an ancient fort at Sankara on the Budh Ganga and other historical places in the same neighbourhood. Mr. Carlleyle claimed also to have discovered at Bhuila Tal, the site of the famous town of Kapilavastu, the birthplace of Sakya Buddha, for many centuries the most venerated of all the holy places of Buddhism. This supposed identification was accepted on a subsequent visit by General Cunningham, who traced there various minor sites associated with the life of Sakya Muni. The identifications were eventually, however, quite disproved by Dr. Führer.

During the same seasons (1874–76) Mr. Beglar was exploring the little-known tracts between Chattisgarh and Cuttak, as well as some interesting places in Rewa and the Central Provinces on the west, and in Orissa on the east. At Ranipur-jural in the State of Karund, there is a very fine example of the Indian Hypœthral temple, of which very few specimens exist, besides many other temples of various periods. The most ancient places visited by Mr. Beglar were the famous sites of Khandagiri, Udayagiri, and Dhauli with their well-known rock edicts of Asoka. The groups of numerous caves at Mara, about 100 miles S.E. of Rewa, are without inscriptions, but are interesting from their extent, as well as from their position, in the heart of a very wild and picturesque country. Of much later date are the fine Brahmanical temples of Chandrehi

and Turturia, of which some views are given in Mr. Beglar's Report.* When these temples were built, the arts of architecture and sculpture in the Central Provinces must have been quite as flourishing as in any other part of India. The temples at Markandi on the Wain-Ganga River, and of Boram Deo in the Kawarda State of Chattisgarh, also bear witness to the same fact. General Cunningham concludes, therefore, that the whole of this part of the country must then have belonged to the powerful Kulachuri Rajas of Chedi, and not to the aboriginal Gonds, whose power was confined to the hills.

Mr. Carlleyle continued, during the seasons 1875–77, his task of endeavouring to identify sites in the Gorakhpur district connected with the early history of the great teacher, Buddha Sakyamuni. He made a complete exploration of the ruins at Kasia, which General Cunningham had already identified with the ancient city of Kusinagara, where Buddha died.† This view is, however, questioned by Professor Oldenburg and others. The ensuing seasons‡ were devoted by Mr. Carlleyle towards following up the further route pursued by Hwen Thsang, who after terminating his visit to Kapilavastu and its sacred neighbourhood, next proceeded in a south-easterly direction to pay his adorations at the various spots where Buddha had passed, after he had left his native place to enter upon the life of an ascetic. The districts, parts of which were traversed by Mr. Carlleyle during the three seasons 1877–80, were Gorakhpur, Saran, and Ghazipur, and in the course of his survey he discovered another inscribed pillar of Asoka at Rampurwa in the Terai, at the foot of the Nepal hills. The inscription is letter for letter the same as that on the two pillars near Betiya. The pillar is lying prostrate, and in its fall the capital was broken, and the lower part of the bell was found attached to the shaft by a massive copper bolt, proving that the Hindus were probably aware of the destructive properties of iron when used as a fastening for stones. General Cunningham believes that the art of stone-cutting was known to the Hindus before the time of Alexander.

In 1878–79 General Cunningham turned his attention to the Punjab, with the object of seeing several of the rather out-of-the-

* Vol. XIII. of the Archæological Survey of India (Cunningham), Calcutta, 1882.

† Vol. XVIII.

‡ Detailed in Vol. XXII.

way places which he had not previously visited, so as to complete as far as possible, a general exploration of the province. The temples at Baghanvala, Malot, and Ketas, were visited by Mr. Beglar, who then proceeded to Ali Masjid to excavate the various Buddhist remains, which had been discovered on the occupation of the place by the British army at the time of the Afghan Campaign. General Cunningham examined all the sites to the south of Manikyala, which had been visited by General Court, and then proceeded to Shahdheri, the supposed ancient Taxila, to explore some spots that had been left untouched by General Ventura. Besides miscellaneous objects, such as figures and ornaments, thousands upon thousands of old Indian coins are found among the ruins of Taxila, which seem to indicate that the Hindus were in possession of a real coinage at the time of Alexander's expedition. After visiting Kafirkot, the General inspected the site of Rohri, where the floods of the Indus had cut away part of the bank, and revealed the remains of an old stupa with numerous Buddhist figures and heads in stucco. The fort of Amb, within the Salt Range, which was visited, still possesses some Hindu temples. The great mound at Jehlam had been described by both Generals Court and Abbott; recent diggings for the railway had brought to light relics dating from the time of the Greeks, and also from the most flourishing period of Kashmirian rule. Passing through Lahore, the General visited the lofty mound of China, 11 miles from Amritsar, which he identifies with the Chinapati of Hwen Thsang, and crossing the Beas River, explored various old sites in the Jalandhar Doab and east of the Sutlej. South-east of Ambala, General Cunningham discovered the village of Topra or Tobra, from which Firoz Shah removed the great monolith of Asoka; and his tour was brought to a conclusion with the examination of the old battle fields famous in Hindu history which are grouped round Thaneswar.*

The following season was devoted by General Cunningham to a tour in Behar and Bengal from Patna to Sunargaon. He first visited Buddha Gaya where he had the good fortune to pick up two dated inscriptions, one fixing the accession of Dharmapala, the second Prince of the Pala dynasty of Bengal in 831 A.D. At Jahngria, the rock sculptures and rock-cut temple of Kahalgaon are

* Vol. XIV., Archæological Survey of India.—Report of a tour in the Punjáb in 1878-79. By Alex. Cunningham, Major-General, C.S.I., C.I.E. Calcutta, 1882.

very interesting, the latter more especially on account of its peculiar style, which differs widely from the highly decorated shrines of the mediæval period. The Muhammadan buildings at Gaur and Hazrat Pandua, the two western capitals of Bengal, were carefully studied.*

Gaur lies about 150 miles north of Calcutta. In former days when the Ganges flowed past the city, Gaur was the great mart where all the sugar of the northern districts was collected for exportation. But since the city was deserted by the Ganges, the sugar is brought to Rahanpur. Gaur was the capital of Balal Sen and his descendants and their successors, the Muhammadan governors and kings of Bengal. General Cunningham thinks that the old Hindu city must have been about 4 miles in length, with a mean breadth of about $1\frac{1}{2}$ miles, while the ruins of the Muhammadan city extend for a length of 11 miles along the Bhagirathi river. When this river dwindled to a mere rivulet, and the refuse of the city was no longer swept away, a deadly pestilence broke out in 1575, and carried off fourteen of Akbar's principal officers and the governor of the province. Since then, Gaur became gradually deserted, and at the end of the last century had become an uninhabited waste, covered with great forest trees and thick jungle, swarming with tigers, leopards, and wild boars, and full of swamps teeming with mosquitoes and crocodiles. But about 15 years ago Government offered the lands almost rent free, and the offer being eagerly taken up by the people, much of the jungle was cleared away. The ruins are very extensive, and are found scattered about the citadel, the city, and the suburbs. They include massive gateways, ramparts, mosques, and other structures illustrative of the prosperous period of the Muhammadan occupation. General Cunningham claimed also to have discovered the site of the ancient capital called Paundra Varddhana by Hwen Thsang in Mahasthan on the Karatoya river.†

* Gaur has been described by the late Mr. J. H. Ravenshaw in a costly volume, excellently illustrated by forty-four of his own photographs, and twenty-five plates of inscriptions. The untimely death of the author in 1874 delayed the publication of the book until 1878.

† Mr. E. V. Westmacott, B.C.S., in January 1874 had identified Paundra Varddhana with Panjara-Borddhonkuti, or Ponrowa and Borddhonkuti (Indian Antiquary, Vol. III., p. 62, and Beal's Hwen Tsiang, Vol. II., p. 194). General Cunningham's tour in Behar and Bengal in 1879–80, is described in Vol. XV. of the Series of Reports of the Archæological Survey of India. The Report contains also some interesting notes on the history of Bengal from the earliest known times down to the 16th Century.

The season of 1880–81 was devoted by General Cunningham to a tour in North and South Behar.* Part of the season was spent in clearing the Buddha Gaya temple, in the course of which the sites of many of the holy places described by the Chinese pilgrims and some traces of the original temple of Asoka were identified. The raised promenade or cloistered walk along which Buddha took exercise was identified, as well as the *vajrâsan*, or famous "diamond throne," on which Buddha was said to have sat under the Bodhi tree. The result of the researches at Buddha Gaya, made in November 1880, and again in February 1881, were fully described in a special joint work by General Cunningham and Mr. Beglar. The following season (1881–82) found General Cunningham in the Central Provinces, exploring the old cities of Rajim, Arang, and Sirpur, the last of which he believes to have been the ancient capital of the country of Maha-Kosala, or Chattisgarh, as it now called, and obtaining copies of their ancient inscriptions. The remains of these three ancient sites differ from other temples in Northern India, not only in their plans, but in their decorations. They present no grand entrance to the front, which is quite open to the full breadth of the nave or hall, the only access being by small flights of steps from the sides. Their spires also are not so lofty as those of the mediæval temples, and their external ornamentation bears a strong resemblance to that of the great Buddhist temple at Buddha Gaya. But the sculptures on the pilasters are all of Brahmanical subjects. From the inscriptions from these old cities General Cunningham was enabled to frame an outline of the history of Maha-Kosala, from the 3rd or 4th Century of the Christain era down to the conquest of the country by the Marathas. He also paid a visit to the great temple of Boram Deo, which is one of the finest buildings in the Central Provinces, both in size and in richness of ornament, but which turned out to be much more recent than previously supposed. The tour finished at Mathura, where General Cunningham was fortunate enough to find a half life-size alto-relievo statue of Herakles strangling the Nemæan lion. It appears to have been copied from some Greek original, and has apparently formed one side of an altar.† The group is now safe in the Calcutta Museum, after having been used as a cattle trough for years.

* Volume XVI., Archæological Survey of India.

† Vol. XVII. of General Cunningham's Reports, dealing with the above tour is accompanied by a note on the aboriginal race of the Sauras or Savaras, and another note on Demon worship, which is intimately connected with the history of the same race.

During the cold season of 1881–82 Mr. Garrick made a tour for the purpose of photographing and exploring the old temples at Markandi. He also examined the remains of an old Buddhist monastery at Barmayan, which General Cunningham is inclined to identify with the monastery built by the Maharaja Sri Gupta for the use of the Chinese pilgrims who visited India. After visiting the ruins of the ancient city of Gurgi, in Rewa territory, Mr. Garrick was deputed to inspect the excavations being made by a company of sappers in the Yusufzai district. Charsada, the ancient Peukalaotis, about two marches north-east of Peshawar, forms a central point of historical interest, well meriting further research.*

The season of 1882–83 was taken up with the exploration of Eastern Rajputana.† In Alwar, General Cunningham visited the old capitals of Tejara, Rajgarh, and Paranagar, with various border forts, famous for centuries in the history of the Meos of Mewat, who, until their conversion to Muhammadanism, so successfully resisted the arms of the Muhammadan kings of Delhi. The principal remains of the Meo rulers, consist of mosques and tombs. A visit was paid to the great fort of Tahangarh, in the Karauli territory, which had previously been unnoticed, although it was formerly one of the great forts of Upper India. It is now quite deserted, and is filled with thick jungle, and infested by tigers. While in this neighbourhood, General Cunningham visited the battle field of Khanwa, where Baber defeated the great Hindu prince Sangram, and his ally Hasan Khan. He also found the Baoli well, built by Baber on the spot where he poured out all the wine in his camp, in fulfilment of a long neglected vow. In the Gwalior territory the chief place visited was the great Jaina temple of Dubkund. It lies in the very heart of deep jungles, and has 35 small chapels round the main building. The whole season's tour was very fruitful in Muhammadan inscriptions.

General Cunningham's last two tours in Bundelkhand and Rewa during the cold seasons of 1883–84 and 1884–85 are recorded in Vol. XXI. of the Archæological Survey of India. In the course of these he visited many places which had not been reported upon by the officers of the Department. The most notable of these

* Vol. XIX., Archæological Survey of India.—Report of a tour through Behar, Central India, Peshawar, and Yusufzai, 1881–82. Calcutta, 1885.

† Described in Vol. XX.

places were the great forts of Kalanjara and Ajaygarh, the strongholds of the Chandels of Mahoba and their religious capital of Khajuraho, which possesses the most famous collection of magnificent temples in Upper India. Two important inscriptions were also found, one at Lakhima, dating from shortly after the death of Skandagupta, and the other, still older, found on the Ginja hill, about 40 miles to the S.W. of Allahabad, and dating apparently from the Seleukidan era, A.D. 140.*

In 1885 General Cunningham resigned his post as Director-General of the Archæological Survey. He had served no fewer than 54 years under Government, having been appointed Lieutenant in the Bengal Engineers on the 9th June 1831.† He was present at the battle of Punniar in 1843, and at the battles of Chilianwala and Gujrat in 1848–9. Cunningham was twice employed in Ladak, and his valuable work on that country is still a standard authority on the subject. In 1861 he was appointed Archæological Surveyor by Lord Canning, as mentioned above (*see* page 326), and, with a brief interval of four years (1866—1870), he was continuously engaged on these important duties up to his retirement. General Cunningham thus summarized his own labours :—

"I have identified the sites of many of the chief cities and most famous places of ancient India, such as the Rock of Aornos, the city of Taxila, and the fortress of Sangala, all connected with the history of Alexander the Great. In India I have found the sites of the celebrated cities of Sankisa, Sravasti, and Kausambi, all intimately connected with the history of Buddha. Amongst other discoveries I may mention the Great Stupa of Bharhut, on which most of the principal events of Buddha's life were sculptured and inscribed. I have found three dated inscriptions of King Asoka, and my assistants have brought to light a new pillar of Asoka, and a new text of his Rock edicts in Baktrian characters, in which the whole of the 12th edict, which is wanting in the Shahbazgarhi text‡ is complete.

"I have traced the Gupta style of architecture in the temples of the Gupta kings at Tigowa, Bilsar, Bhitargaon, Kuthera, and Deogarh, and I have discovered new inscriptions of this powerful dynasty at Erau, Udayagiri, and other places.

"In illustration of my explorations and discoveries, I have published the following works :—

"1. The Temples of Kashmir.

"2. The Bhilsa Topes or Buddhist Monuments of Central India.

"3. Ladak, Physical, Statistical, and Historical.

"4. Geography of Ancient India.

"5. Coins of Alexander's Successors in the East.

* Vol. XXI., Parts I. and II. Archæological Survey of India.

† He was son of Allan Cunningham, the well-known poet and man of letters.

‡ The twelfth edict has since been discovered at Shahbazgarhi, and published in the "Epigraphia Indica."

"6. Corpus Inscriptionum Indicarum, Vol. I., Inscriptions of Asoka.
"7. Stupa of Bharhut.
"8. Book of Indian Eras, with Tables for the Calculation of Dates."

These works, it may be observed, were, in addition to the series of 23 volumes of the Archæological Survey Reports, written by General Cunningham and his assistants, and reviewed in the present chapter.

In accepting General Cunningham's resignation, the Governor-General in Council "had much pleasure in tendering to that officer "the thanks of the Government of India for the distinguished "service rendered by him during an unusually long career." General Cunningham was created a K.C.I.E. soon after, and in 1887 a special pension of Rs. 2,000 per annum, in addition to his military pension, was rendered to him for his distinguished services as Director-General of the Archæological Survey.

On the retirement of General Cunningham the Department was re-organised on a plan proposed by him. The Northern Provinces were divided into three charges or circles, each being entrusted to a surveyor, with a suitable establishment. In the Madras and Bombay Presidencies, the existing arrangements were left undisturbed under Dr. Burgess, but that officer was constituted the head of the entire Survey Department, and the channel for the submission of the annual reports of each survey party to the Government of India. The surveyors, in addition to the strictly archæological portion of their work, were placed on the footing of professional advisers to the local governments in regard to the repair and restoration of buildings of antiquity. These arrangements were sanctioned for a period of five years from the 1st October 1885, but were modified early in 1886 by the appointment of Dr. Burgess as Director-General for all India. Efforts were now made by Dr. Burgess to utilise some of the material already collected. Provincial surveys had been conducted at a good deal of expense, both in the Punjab and North-Western Provinces by officers of the Public Works Department for several years previously; and much attention had been devoted to the great monuments of Agra, Jaunpur, Delhi, Lahore, &c. On examination of the drawings, however, Dr. Burgess found that the details on which so much of the real character and style of architectural art is dependent had not been drawn with sufficient care. Many of the smaller measurements were in error, and the proportions of ornamental work, mouldings, &c. overlooked. In the case of Jaunpur it was found that the whole

had to be re-measured and re-drawn. This work was entrusted to the architectural assistant of the North-West Provinces survey, Mr. E. W. Smith, who conducted a very careful survey in 1886 and 1887.

The report on "The Sharqi Architecture of Jaunpur, with notes on Zafarabad, Sahet-Mahet, and other places in the North-Western Provinces and Oudh," appeared in 1889.* The bulk of the letter-press was by Dr. Führer, and the architectural descriptions were by Mr. Smith, while Dr. Burgess acted as controlling Editor. To the manuscript of his report Dr. Führer added a bulky appendix of 46 Arabic, Persian, and Sanscrit inscriptions collected during his tour. Many of these were unknown before, and some were of great historical importance, especially in settling the question of the time of the first appropriation of the ancient Buddhist and Hindu temples by the Muhammadans.

Jaunpur possesses much historical interest, as along the banks of the Barna are the sites of large cities, destroyed by fire. On the Gumti stood vast temples which perished on the first inroad of the Musalmans; but what founders and what antiquity these cities and temples boasted none can now say. The chief attractions of Jaunpur are its masjids, which are unique in style and grandeur, their general features being exemplified by those of the Atala Masjid, which consists of a courtyard, on the western side of which is situated a range of buildings, the central one covered by a dome, in front of which stands a gate-pyramid or propylon of almost Egyptian character and outline. The three sides of the courtyard were surrounded by colonnades, and on each side was a handsome gateway. "These Jaunpur examples are well worthy of illustration, " and in themselves possess a simplicity and grandeur not often met " with in this style."†

Dr. Führer remarks of this town:—

"If in a visit to Jaunpur there be melancholy, yet is that melancholy free from pain. You stand amid ruins, but ruins defiled by no painful memories. Not here does each building recall centuries of blood, and lust, and crime. From the pinnacles of the Jami masjid you look down on the ghost of a noble city: trees growing where once stood the palaces of princes. From the mound of the Fort, now so desolate, you look down on the fair valley, bright with the meanderings of the Gumti, adorned with trees and the thickly set tombs of men, many, doubtless, heroic men, though their deeds be forgotten, *quia carent vate sacro.* As you look down from the upper chambers into the central hall of the Jami masjid, when, as the evening draws on, the deepening gloom

* With 74 plates; printed and published by the Superintendent of Government Printing, India. Calcutta (Thacker); London (Trübner and Allen), 1889.

† Fergusson:—History of Indian and Eastern Architecture, pp. 522–524.

and the dimmer distance makes you feel as standing in a noble shrine of a more familiar faith, the voice of some worshipper below, echoing through the vaults, carries you back to a time when, through the same lattice, some queen looked down on king and nobles gleaming in the light of pendant lamps, with the gold and jewels of an Eastern court, as they listened to the words of some saintly philosopher seated on that very pulpit."

Other places visited and described in the same volume by Dr. Führer are Zafarabad, Ayodhya, Bhuila Tal, and Sahet Mahet. But the plans, elevations, and other lithographs all treat of the Jaunpur masjids, which form the most interesting feature of the work. Dr. Führer has since made tours in Bundelkhand, Jhansi, Rohilkhand, and Allahabad districts, and has completed the excavation of the Kankali mound at Mathura, begun by Dr. Burgess in 1887, discovering many very ancient and important Jain inscriptions and sculptures. Mr. Smith, the architectural assistant in this circle, also made careful drawings, in 1886–87, at numerous sites in Bundelkhand; in 1888, at Budaun; in 1888–89, at Kalpi, Irich, Urchha, and Lalitpur; and in the following two seasons, a most important series of the richly decorate darchitecture of Fathepur Sikri.

In 1885-86, Mr. J. D. Beglar, General Cunningham's former assistant, made a tour in Bengal, but his report was not altogether satisfactory. Mr. H. W. B. Garrick was engaged during this and the following season at Sasseram and Rohtas, making architectural drawings of the monuments at these places; in 1888–89, he made a tour through northern Bengal, and obtained good facsimile impressions of two sets of the Pillar Edicts of Asoka, and of so much of that on the Rampurwa Pillar as was practicable, the pillar lying on its face. In 1887–88, Mr. Beglar was principally employed at Gaur and Pandua, and made a considerable number of drawings.

Mr. Rodgers joined the Survey of the Punjab in January 1886, and during that season and the following two, he made surveys at Nurpur, in the Kangra valley, and in the Jalandhar, Ambala, and Hissar districts, making a very considerably number of drawings and impressions of inscriptions, which it is intended to publish. He also made a large collection of ancient coins. In 1888–89, he made a tour in Karnal, Ambala, and Ludhiana districts, during which his staff prepared a large number of drawings.

Archæology has suffered greatly in India, as elsewhere, from the appropriation by private persons of such antiquities as come to light from time to time. Sculptures, rings, coins, engraved seals, gems,

and other relics have been occasionally carried off by officers of Government, both civil and military,* for their friends and to present to distinguished visitors and tourists, or to adorn their houses and gardens at home, at Simla and elsewhere. The demand and prices offered for such objects have become so great that natives are induced to search for them everywhere, both in British territory and in Swat, and neighbouring sites, where ancient Buddhist buildings of high interest exist, and owing to the random fashion in which the excavations are made, sculptures get mixed up, and their history and meaning are lost. Dr. Burgess mentions a case of three interesting, but practically unknown, statues of royal personages, which were transferred to the mess house at Mardan. Two of them were doing duty as jambs to the fireplace, and had been coated with Day and Martin's blacking to make them shine properly. Dr. Burgess advised an amendment of the Treasure Trove Act VI. of 1878, which would make it illegal, as in Greece, Italy, and Denmark, to export antiquities without an official permit. But the Government, on consideration of the question (*see* Resolution and Circular $\frac{21}{4-2}$ Arch. Proceedings, R. and A., dated 28th March 1889), did not see their way to adopt so drastic a course, and decided to call the attention of the local governments to the provisions of the Treasure Trove Act, which permits the government to claim possession of treasure exceeding ten rupees in value. With regard to antiquities of interest which could not be brought under the definition of "treasure" in the Act, they advised negotiation with the finder with a view to purchase.

An important appeal had been made to the Secretary of State in July 1873 in the shape of a memorial, signed by many of the most eminent statesmen and men of letters of the day, and urging the necessity of adopting systematic measures for the preservation of historical monuments in India. A few months before, the Government of India had pointed out, in a circular to the Local Governments, that it was the duty of all executive engineers to report upon the best measures for protecting from decay any public monument or building of interest, whether public or private. With a view to obtaining complete information regarding the architectural and historical monuments of the Bombay Presidency, Mr. Burgess was requested to frame provisional lists for the different collectorates of the Bombay Presidency and for Kathiawar, Gujrat,

* *See* Memoranda of Dr. Burgess and Major Keith in the Proceedings of the Government of India (R. and A. Department), No. 3 (Archæology), April 1889.

the Central Provinces, and Berar; and a revised batch of those provisional lists* was published in 1875 as one of the *fasciculi* memoranda of the Archæological Survey of Western India.†

A list of the remains in Khandesh was prepared by Mr. Propert, the collector, and issued in 1877‡ as No. 7 of the *fasciculi* of the Western India Survey, and the same year saw the publication of some "Notes" by Mr. W. F. Sinclair, Bo. C.S., assistant collector, Ahmadnagar, on the antiquities of the Talukas of Parner, Sangamner, Ankole, and Kopargaum, together with revised lists of remains in the Ahmadnagar, Nasik, Poona, Thana, and Kaladgi Zillas. These were issued as No. 6 of the same series of *fasciculi*. The latter was accompanied by a useful memorandum by Mr. Burgess, giving practical suggestions for identifying and correctly describing the local antiquities. The complete lists appeared in No. 11.

Among the other *fasciculi* of this series, No. 9 (1879) contains notes on the Bauddha Rock-temples of Ajanta, their paintings and sculptures; and on the paintings in the Bagh caves in Central India; illustrations of modern Bauddha mythology; and the Sanskrit inscription now at Cintra, with 31 plates. This contains a full description of the famous frescoes of the Ajanta caves. No. 10 (1881) contains inscriptions from the cave temples of Western India with descriptive notes, a Silahara copperplate grant, and three Sanskrit inscriptions now in possession of the American Oriental Society. This is illustrated with 52 plates chiefly fac-similes of inscriptions, and was compiled jointly by Dr. Burgess and the late Pandit Bhagwanlal Indraji, Ph. D. The last addition to the series is No. 12 (1891) on the newly discovered Buddhist caves at Nadsur and Karsambla (with seven plates) by Mr. H. Cousens.

In April 1880 the Government of India placed Captain H. H. Cole, R.E., on special duty for the purpose of examining the

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* The first edition of this List, with a Memorandum on the Survey of Architectural and other remains had been submitted to the Government of Bombay in August 1870, and was reprinted in the Minutes of the Government of India in March 1871.

† No. 4. Provisional Lists of architectural and other archæological remains in Western India including the Bombay Presidency, Sindh, Berar, Central Provinces, and Haidarabad. By Jas. Burgess, Bombay. Government Central Press, 1875.

‡ Architectural and archæological remains in Khandesh in 1877. Bombay Government Central Press. No. 8 of the same series of Memoranda contains a descriptive list of Archæological Remains in Sindh, with plans of Tombs, compiled from returns by the District Officers, 1879. For No. 11, *see* p. 346.

condition of the monuments of Lahore, Delhi,* and Agra. Captain Cole instructed draughtsmen to measure and draw the structures, and submitted a report. In the following year, Captain Cole was gazetted Curator of Ancient Monuments in India, and received instructions to inspect the principal monuments throughout India, a duty which occupied him up to the 7th April 1882. His first report† contained a brief history of some of the chief measures taken during the century to preserve the monuments of India, lists of remains, and of works of reference, and some rather interesting detailed notes on structures and antiquities in the various provinces visited by him during the year.

The second report appeared in 1883.‡ It furnished a list of the drawings, sections, elevations, and plans made by Major Cole's officers, and an account of his own rounds of inspection, besides archæological reports from several of the Local Governments. In more than one of the provinces some useful steps had been taken. Mr. Grant Duff, Governor of Madras, had been touring through the Southern Presidency, and his visit had given an impetus to archæological conservation and research. A special officer was appointed to undertake the repairs of the Madras monuments, the appointment being offered to, and accepted by, Mr. F. C. Black, C.E.,§ who forthwith proceeded to Hampe or Bijayanagar, and the Seven Pagodas. At Bijayanagar the work of conservation was vigorously taken in hand, and 110 buildings cleared of jungle; and at the Alaiva or Shore Temple at Seven Pagodas, the sand was cleared away from the walls of the outer enclosure. For Central India, Major Keith was appointed Assistant Curator, and was despatched to Sanchi to effect clearances, to re-erect the fallen gateways of the Great Tope, and carry out other repairs. This work was put in hand, and by

* A work on "The Archæology and Monumental Remains of Delhi" (281 pp. 8vo.), was produced by Mr. Carr Stephen, in 1876 (Ludhiana). It contains a description and history of every object of antiquarian interest in the place, beginning with the site of the semi-mythical India-prastha, the capital of Yudishthira, which is supposed to date back to 1450 B.C., and concluding with the tomb of the Emperor Akbar II., who died in 1837 A.D.

† Published at the Government Central Press, Simla, 1882.

‡ Second Report of the Curator of Ancient Monuments in India for the year 1882–3. Calcutta: Superintendent of Government Printing, 1883.

§ Mr. F. C. Black contributed several papers on archæological subjects to the Journal of the Asiatic Society of Bengal. He died in 1889. A brief record of his public services will be found in the Minutes of Proceedings of the Institute of Civil Engineers, Vol. XCVIII., p. 402.

the end of the year quite a transformation had been effected. In the Punjab a grant of Rs. 38,000 was allotted out of the Government of India grant, and Lieutenant Abbott, R.E., was placed in charge of the operations, which consisted of the restoration of various important monuments and buildings at Lahore, Delhi, and in the Jalandhar district. Excavations were also carried out in the Yusufzai district, north-east of Peshawar, and several new sculptures, illustrative of the Græco-Baktrian style of art were brought to light. Illustrations of some of these are appended to Major Cole's report. In the North-West Provinces, the operations were mainly entrusted to Mr. Heath, who made many useful restorations in the Fort of Agra, at Akbar's tomb at Sikandra, at Fathepur-Sikri, Mathura, and Brindaban;* and in the Nizam's dominions a report was obtained from the Sadr Talukdar promising to take steps to effect several works of restoration at Kalburga and other places.

Major Cole's third Report† was the last of the Series, for in 1883 the Government of India decided to entrust the work of preserving buildings and monuments of importance to the Local Governments, who were also desired by the Government of India‡ to take up the preparation of the lists of ancient monuments, dividing them into three categories:—

I. Those monuments which form their present condition and historical or archæological value ought to be maintained in permanent good repair.

II. Those monuments which it is now only possible or desirable to save from further decay by such minor measures as the eradication of vegetation, the exclusion of water from the walls, and the like.

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* Mathura and Brindaban have been treated in scholarly detail in "Mathura: a District Memoir," by F. S. Growse, B.C.S., M.A., Oxon., C.I.E., second edition (N. W. Provs. and Oudh Government Press, 1880).

† Published at Calcutta in 1885. Major Cole also engaged in survey work, and obtained sanction for a grant of Rs. 5,000 towards reproducing some of the drawings made. But great expense was incurred by the French firm entrusted with the work, and after 42,000 francs had been spent on 61 heliogravure photographs and 42 lithographs, further expenditure was stopped by order of Government. The drawings were distributed in 10 folio parts, without title page.

‡ Resolution of Home Department (Archæology) No. 3—168—83, dated Calcutta, 26th November, 1883.

III. Those monuments which from their advanced stage of decay or comparative unimportance it is impossible or unnecessary to preserve.

The monuments in Classes I. and II. were to be further subdivided, thus—

I. (*a*) and II. (*a*). Monuments in the possession or charge of Government, or in respect of which Government must undertake the cost of all measures of conservation.

I. (*b*) and II. (*b*). Monuments in the possession or charge of private bodies or individuals.

Due provision was to be made for the proper custody and keeping up of the monuments in Classes I. and II., the detailed arrangements being left to the discretion of the Local Governments, and the cost being charged to the Public Works Allotment of each province. In very special cases the Government of India promised to consider whether any further assistance should be granted from Imperial funds.

But when all these lists eventually came to be submitted, they were found to be drawn up on such very dissimilar plans, that a satisfactory amalgamation was hopeless. A prescribed form, containing blank spaces for insertion of all necessary particulars respecting the district, locality, name of object, any local history or tradition regarding it, custody or present use, present state of preservation, whether restoration is desirable and possible, whether photographs, plans, or drawings of the buildings exist, and miscellaneous remarks, was sketched out and the old lists were returned to the various provincial administrations to be revised in consultation with the Archæological Department. Those for Madras, Bombay, and the Haidarabad assigned districts were drawn up and edited by Dr. Burgess.

The Bengal list had been printed in 1879, and a revised list was issued from the Bengal Secretariat Press in 1887. In 1885 the lists of antiquarian remains in Bombay, Sindh, and Berar were published. They had been compiled by Dr. Burgess from materials supplied by the Revenue, Educational, and other officers, and the task had proved anything but easy, owing to the unsatisfactory character of the data frequently furnished. A very favourite description was "This temple consists of stones placed one upon another," an account which failed to

convey any very precise idea of the structure, while the measurements, numbers of columns, &c. given by different officials respecting one and the same building were too often wildly at variance. Nevertheless the lists were a most important step towards a thorough knowledge and systematic preservation of the antiquarian remains of Western India, and they also served to show how wealthy the Bombay Presidency is in such antiquities. The various lists united, formed a volume of 340 pages.* The latest addition to these lists was issued in June 1891, containing a complete résumé of the antiquarian remains and inscriptions in the North-West Provinces and Oudh, compiled by Dr. Führer.† In this large volume Dr. Führer has given a very full account of the remains at each place with references to all sources of information, the whole being carefully classified with complete indices. Dr. Führer is known to have also made extensive collections in 1886–89 for a similar list for Central India.

Western India.—In 1871 proposals were made by the Secretary of State for India for the preparation of a complete work on the rock-cut temples of Western India, in consequence of which a scheme was submitted by the Bombay Government in 1873, and Mr. J. Burgess‡ placed in charge of the operations, the area of investigation being the Bombay Presidency and surrounding native states. Mr. Burgess's first season's work lay in the Belgaum and Kaladgi districts in the Southern Maratha country. At Belgaum he took photographs and made plans of the Jaina temples as well as estampages of the inscriptions. A visit was also paid to

* Lists of the antiquarian remains in the Bombay Presidency. Compiled by James Burgess, LL.D., C.I.E., Bombay (Government Central Press, 1885). An Appendix to the work contains a large number of inscriptions, viz.:—Persian, Arabic, and Sanskrit inscriptions from Gujarât, Persian and Arabic inscriptions from Cambay, Sojâli near Mehmudâbâd, Dholka, and Bharoch, and Sanskrit inscriptions from Girnar. This is No. 11 of the Memoranda noticed above on p. 342.

† "The Monumental Antiquities and Inscriptions in the North-Western Provinces and Oudh, described and arranged by A. Führer, Ph.D." (Allahabad, Superintendent, Government Press, North-West Provinces and Oudh, 1891). Super royal 4to. 426 pages.

‡ Mr. Burgess had already published a large portfolio of photographs with letter-press description of the Satrunjaya Temples near Palitana; another on Somnath, Junagadh, Girnar, &c.; and a third of Architecture and Scenery in Gujarat and Rajputana; a monograph on Elephanta, illustrated (1871); papers on Elura and Ajanta Cave Temples, and Notes of a Visit to Gujarat, and had started and was then editing the Indian Antiquary.

the large Jaina temple of Panchalinga at Huli. All round Huli there are enough carved stones to illustrate a mythology, and Mr. Burgess remarks that if there were a provincial museum at Belgaum, abundant materials to furnish it would be found at Huli. At Badami there are some fine specimens of cave temples, three of them being Brahmanical, and the fourth Jaina, and all probably belonging to the sixth century. The third cave is the finest of the series, and, in some respects, one of the most remarkable Brahmanical works in India. Though it cannot compare with Elephanta or the Dumar Lena in size, yet it is a large cave filled with a variety of sculptured brackets, statues, carved pilasters, and the like. In this he found an inscription dating from 579 A.D. which has afforded an invaluable fixed point for the chronology of the Brahmanical caves. The great Saiva and other Dravidian Temples at Pattadkal were also surveyed and delineated.*

Mr. Burgess's second report dealt with Kathiawar and Cutch. Cutch had up to that time been a *terra incognita* to the antiquarian, and, though not very rich in remains, it deserved a careful examination. Kathiawar was more famous as the Holy Land of Western India. It was known to the Greeks and Romans under the name of Σαυραστρήνη, the Muhammadans called it by the Prakritised name of Sorath, and the Marathas extended the name of Kathiawar from a central district inhabited by the Kathi tribe, to the whole province; but by Brahmans and natives it is still spoken of as Surashtra. It was doubtless at a very early period brought under the influence of Brahmanical civilisation, and from its position was most accessible to influences from the West. As early as the reign of the great Asoka of Magadha (B.C. 265–229) we find him inscribing his famous edicts upon a huge granite boulder at the entrance of the pass leading from Junagadh to Girnar. Surashtra was also probably included in the conquests of the Indo-Scythian kings in the second century before Christ.† Its shores were well known to the Alexandrian merchants a few centuries later, but there is much difficulty in identifying the places.

One of the most important of Mr. Burgess's researches consisted in the discovery of some interesting specimens of the coins of the local Kshatrapa kings of Surashtra and their imperial Gupta successors.

* *See* Fergusson's Indian and Eastern Architecture, p. 439 ff. Mr. Burgess's first season's report was published in 1874 by Messrs. W. H. Allen & Co., and was accompanied by numerous photographs, lithographed plans, details, &c.

† Strabo, lib. xi. cap. xi, 1.

The domination of this race had previously formed an important but undefined epoch among the dynastic revolutions of India, and the late Mr. Edward Thomas, the well-known numismatist undertook the arrangement and classification of the coins.* Some of these coins bear legends in imperfect Greek, the Greek language having followed the conquering progress of the Baktro-Hellenic kings as far as Mathura, Oudh, and Patna, and having been reserved more exclusively for the ruling classes during their brief sway, while the Greek alphabet in a degraded form was preserved still longer. It is singular that there is no trace of any solitary inscription in the Greek language in India, but in its numismatic form it remained the leading vehicle of official record for more than two centuries, under Greek and Scythian auspices.

The conquest of Sind by the Arabs in A.D. 712 was a marked epoch in the annals of the country, associated with some instructive coincidences, such as its inception, the ready domestication of the conquerors on an alien soil, their final ethnic absorption into the Indian native element, and their abrupt disappearance into comparative obscurity. Several coins discovered by Mr. Burgess are ascribed by Mr. Thomas to this period.

At Junagadh, one of the most ancient cities of India, there is probably a rich mine of buried antiquities, and the rock inscription about a mile west of the city is the most interesting archæological relic in the province.† It is approached by a noble avenue of mango and *jamun* trees, terminating in a substantial causeway and bridge over the Sonarekha. The memorial itself is a huge hemispherical mass of grey granite covered with 14 tablets or edicts of Asoka,‡ besides a Kshatrapa and a Gupta inscription. This rock-cut lettering extends over considerably more than a hundred square feet, The edicts are in the Pali dialect and character, and contain a variety of injunctions as to moral behaviour, public orders, the sparing of animal life, religious tolerance, and the like. Professor Kern

* Mr. Edward Thomas was the author of the third chapter of Mr. Burgess's Report, dealing with the Sah and Gupta coins.

† It was visited and described by Major James Tod (Travels in Western India, p. 369).

‡ The other edicts are at Dhauli, in Cuttak, at Kalsi, on the banks of the Jamuna, at Jaugada Naugam, in the Ganjam district, near the coast of the Bay of Bengal (these three being, like that near Junagadh, in the Pali character), at Shah-baz-garhi, about 36 miles N.E. of Peshawar, and at Mansahra in the Hazara district (both n the Baktrian character).

remarks that these edicts give an idea of what the king did for his subjects in his wide empire which extended from Behar to Gandhara, and from the Himalayas to the Kalinga coast. Asoka the Humane went over to Buddhism in the eleventh year of his reign and became a zealous religionist, but he was a good prince, and tolerant towards the other faiths, as is exemplified in his edicts.

The Buddhist caves of Junagadh, Talaja, Sana, &c. form another feature of interest in Kathiawar. Hwen-Thsang, the Chinese pilgrim of the seventh century states that there were in his time about 50 convents here with about 3,000 recluses. Of these Buddhist convents remains still exist, though four centuries of Moslem dominion and strife have obliterated nearly every trace of most of them. The rock-cut caves at Junagadh were probably excavavated for the Jainas by the Sah or Kshatrapa kings of Surashtra about the end of the second century A.D. Mount Girnar was doubtless a place of pilgrimage, even before the days of Asoka, and in his time it probably became a Bauddha sacred place where monasteries were early formed and cells cut in its granitic scarps for the devotees. The Jaina temples here form a sort of fort, perched on the ledge at the top of the great cliff; they are 16 in number, and some present a majestic appearance with their boldly carved granite pillars. There is a striking example of modern indigenous art at Junagadh in the tomb of Maiji Sahiba, the mother of the late Nawab of Junagadh. From a low platform rise 20 rich and elegant columns supporting the colonnade or verandah surrounding the tomb. The carving is most elaborate and florid, though Mr. Fergusson considers the details inappropriate for stonework and the style not in accordance with the true principles of constructive design. The town of Jamnagar is of recent origin, and there is not much of antiquarian interest in it, but the façade of the palace and the Delhi gateway, two capital photographs of which were taken by Dr. Burgess, are good specimens of modern Hindu architecture.

The history of Cutch is involved in great obscurity. But perhaps the most important, as it certainly was the most disastrous, event connected with the architectural remains of the province was one of comparatively recent date, *i.e.*, the great earthquake of the 16th June 1819, which extended from Nepal in the north to Pondicherri in the south, and from Makran in the west to Calcutta in the east, but the force of which most violently affected Cutch and the region

immediately north of it. This convulsion totally ruined many of the oldest buildings in Cutch, the effect being particularly disastrous at Anjar and Bhuj, where thousands of houses were ruined or rendered uninhabitable. Dr. Burgess had only time to examine the eastern part of the province, which is not very rich in antiquarian remains, though there are some noticeable Jaina shrines and temples at Bhadresvar, Keda, and Kotai. But the return journey through Gujrat proved more fruitful, and the photographs of the gates at Dabhoi and Jhinjuwada, sister fortresses of very similar construction, convey a good notion of the massive and elaborate structural and decorative character imparted to it by the Hindu architects of the twelfth century.

The general results of the season's operations from the 26th October 1874 to the 24th April 1875 are set forth in a report of 242 pages,* accompanied by a map and numerous photographic and other illustrations.

The third report of the Archæological Survey of Western India describes the principal remains examined during the annual tour made in the cold season of 1875–76, through the western districts of the territories of His Highness the Nizam. The tracts had been previously quite unknown to the antiquary, but though near to Kalyana, an ancient capital of the great Western Chalukya dynasty, the survey did not yield either coins or inscriptions, the wholesale destructions effected by the Muhammadan arms being doubtless one cause of this. The latter part of the season was mostly spent at Aurangabad, when a thorough survey was made of some interesting, but little known groups of Buddhist caves in the neighbourhood. The Chalukya race is the oldest of which satisfactory mention is made in the records of the Deccan, and they seem to have belonged to the great nationality which under the name of Rajputs exercised dominion over the whole of Northern and Central India. The rule of the Chalukyas extended from the Narmada on the north to the Tungabhadra to the south, and from the Arabian Sea on the west, to the Godavari and the Eastern Ghats on the north-east and south-east. After a visit to Bidar, a city which still contains, after nearly three centuries of desertion and neglect, many remains of the grandeur of the Bahmani and Berid dynasties, Mr. Burgess proceeded to Paithan, the Παίθανα

* Archæological Survey of Western India.—Report on the antiquities of Kathiawar and Kachh. By James Burgess, F.R.G.S., M.R.A.S. (Allen & Co.), 1876.

of the Greek writers, and one of the capitals of the Andhras, whose rule extended over the Telugu country and the northern Deccan, including Nasik. Their monarchs were of great in power the early centuries of the Christian era, for Pliny states that their king possessed 30 walled towns, and could bring into the field 100,000 foot, 10,000 horse, and 2,000 elephants. The author of the *Periplus of the Ærythrean Sea* speaks of Paithana as a most notable trading place, and famous for onyxes, which are still found in abundance there. The place abounds in local legends, but its architectural magnificence has long since disappeared, though many rich and beautiful patterns of wood-carving on the doors balconies, and railings of houses, built a century ago or more, are to be seen. Some elegant specimens of these are lithographed in Mr. Burgess's book. Formerly the manufacture of silk shawls at Paithan was famous throughout India, but it has now ceased to enrich the place, a ruinous tax having been imposed, which drove most of the weavers away, and destroyed the principal source of trade. The Buddhist rock-cut temples at Aurangabad had received no attention previously to Mr. Burgess's visit. One of the most noticeable features is the remarkably ornate character of the pillars, illustrations of several of which are given by Mr. Burgess. A good photograph of the elegant square pyramidal tower over the shrine of the Ahalyabai temple at Elura also finds place in the volume, as well as facsimilia and translations of numerous important inscriptions.

Mr. Burgess's fourth volume is entitled "Report on the "Buddhist Cave Temples and their inscriptions, being part of the "results of the fourth, fifth, and sixth season's operations of "the Archæological Survey of Western India, 1876–79. Supple-"mentary to the volume on 'The Cave Temples of India.'"* It does not profess to be a complete report in itself, but to afford a good deal of additional material for the study of Buddhist cave architecture which could not be comprised within the limits of the second part of the work on the Cave Temples published the previous year.

The principal object of that work had been to present a general survey of all known examples of Indian rock-cut architecture. They number over a thousand in all, and though the greater

* "The Cave Temples of India," by Messrs. Fergusson and Burgess, was printed and published by order of the Secretary of State for India in 1880.

part are found in the Bombay Presidency and immediately adjoining districts, others exist either singly or in groups both in Bengal and Madras, but under forms as various as the localities are distant from the typical examples of Western India. Another source of complexity arises from the caves being divided among the three principal religions which prevailed in India during the ages in which they were excavated. The oldest and most extensive series belong to the Buddhist religion, whose votaries were the first, and for long perhaps the only, cave excavators. They were succeeded by the Brahmanical caves, when that faith in its turn replaced the once dominant religion of the "mild ascetic." A smaller, but hardly less interesting series of caves belongs to the Jains, who at a later age sought to rival the Brahmans in the magnificence of their rock-cut architecture. Their ages, too, vary greatly. The oldest of all are the simple cells excavated for the Buddhist monks during the reign of Asoka (B.C. 263–225) or immediately after that date, in the granite rocks of Behar, and the series extends down to the most modern Buddhist caves at Ajanta or Aurangabad, probably as late as 700 A.D. The Brahmanical caves overlap these by a hundred or a hundred and fifty years, and may extend down to the tenth century, while the Jaina excavations, commencing about the same time as the Brahmanical were continued in the rock at Gwalior down to the middle of the fifteenth century.

Except in Mr. Fergusson's work on the rock-cut temples of India, published in 1845,* no such general survey of the whole subject had been previously attempted. Since then, however, new series of caves have been discovered, inscriptions have been deciphered, and generally such progress has been made, that a new and greatly enlarged work became indispensable. The principal caves described in Mr. Burgess's Vol. IV. are at Bhaja, Bedsa, Kondane, Nasik, Junnar, Kanheri, and Ajanta. The latter important group of monasteries and temples had already occupied three chapters, and 35 illustrations in the work on the Cave Temples, but the interest attaching to their varied architecture, sculptures, inscriptions, and paintings, which exhibit so much of the history of Indian art for a period of so many centuries, led Mr. Burgess to present numerous additional details and descriptions in his fourth

* Illustrations of the Rock-cut Temples of India:—18 plates in tinted lithography (folio), with an 8vo. volume of text, plans, &c. London: Weale, 1845.

volume. All the important inscriptions found in the caves were translated, and with a general chapter on Palæography, were added to the same work.

Volume V. (1883) illustrated, in the same way as its predecessor, the remaining rock temples of Western India, the principal of which are the well known and magnificent group at Elura, consisting of splendid representatives of Buddhist, Brahmanical, and Jaina cave temples, the Brahmanical and Jaina caves at Badami, at Aihole, at Ankai-Tankai, and at Patna, and the Brahmanical caves, chiefly at Jogeswari on Salsette Island, at Elephanta, at Lonad, and at Harischandragad. Of the Elura temples, M. Baudrillart observes, "At the sight of these astounding "edifices, the development of the plastic arts and of public "religious luxury among the Hindus receives the most striking "attestation in the magnificence of these temples in the infinite "diversity of their details and the minute variety of the "carvings."* The only other Indian group that can rival it, is that at Ajanta. There, however, the caves all belong to the Buddhist religion, and carry on its history and architecture for nearly 1000 years, while those at Elura, commencing when the excavations at Ajanta ceased, acquire additional interest by the introduction of Hindu temples of a novel form, and subsequently by other temples of the Jaina faith, which afford a varied picture of the mythology of India during its period of greatest vigour. The whole group culminates worthily in the Kailasa, the most magnificent rock-cut temple in India.

The village of Elura is in the Nizam dominions about 13 miles north-west of Aurangabad, and the caves are about half a mile east of the village. Cave X. of the Buddhist group is the great Chaitya rock temple and is conspicuous with a fine façade and large open court in front surrounded by a corridor. Here can be traced an interesting architectural development. First, there was in the earliest caves a great open front covered by an external screen, which screen was originally of wood, as at Bhaja, and then of stone, ornamented in wood, till at last it came to be constructed entirely in stone, the opening shrunk in dimension till the screen in front disappeared altogether, as in this instance, and the characteristic external features became obscured.

* Histoire du Luxe Privé et Publique depuis l'antiquité jusqu' à nos jours.

The Kailasa or Rang Mahal Temple No. XVII. of the series as reckoned from the south, has been pretty fully described in the *Cave Temples of India*. It was probably constructed in the reign of Dantidurga, the great Rashtrakuta king (in A.D. 730–755) and is the most extensive and elaborate rock-cut temple in India, as well as the most magnificent of all the architectural objects with which that country abounds. Long, too, after the great temple was finished, works were carried on at different points in the surrounding rock, shrines and images being added until probably the inroads of the Muhammadans finally put a stop to them. The Brahmanical caves north of Kailasa, except the Dumar Sena, are not so notable, but the two principal Jaina caves are very remarkable both in extent and elaboration. They are later in point of date than the caves belonging to the two other sects.

Volume V. also deals with various other caves including the famous Elephanta cave in Bombay Harbour which has, of course, been described by numerous authors and archæologists such as W. Erskine, Wilson, Hunter, and Dr. Burgess himself in 1871. The inscriptions obtained during Dr. Burgess's archæological tours have been discussed by Professor G. Bühler, C.I.E., of Vienna, in the same report, one chapter being devoted to the famous Nanaghat inscriptions, which belong to the oldest historical documents of Western India, and others to the Kanheri and Dasa Avatara inscriptions.

In 1880, the survey of the Ajanta caves and others in the neighbouring districts was completed and the examination of the Chalukyan temples was begun in the south-east of the Dharwar district in 1881, and continued in 1882 chiefly in Belgaum. In 1883–84 the Muhammadan architecture of Gujrat, especially at Champaner, Dholka, and Ahmadabad,* was partly surveyed, and an extensive and important series of drawings begun. In 1885 H.H. the Gaikwar of Baroda requested that the survey should take up the ancient city of Dabhoi; this was done by Mr. Cousens, and the result published at

* In 1886 Mr. A. W. Crawley Boevey, Bo. C.S., published "A Scheme for the "Protection and Conservation of Antient Buildings in and around the City of "Ahmadabad," (folio, pp. 72 and xcv.) Bombay; Education Society's Press; which contains a valuable account of the history of the management of the public buildings about Ahmadabad, with suggestions for their better preservation. This is accompanied by a very full list of the Muhammadan mosques and tombs in and around the city, with notes on their condition, &c. Conf. Journal Royal Institute of British Architects (N.S.), VII., p. 309.

the expense of H.H. in a handsome volume with 22 plates, the letterpress being by Dr. Burgess.* The surveys of Broach and Cambay were carried out, and early in 1886 the work in the Kanarese districts was resumed. In 1886–87 a further survey was undertaken also on behalf of the Gaikwar, and Mr. Cousens with the staff made a tour through a portion of Northern Gujrat, visiting Siddhpur, Patan, Mudhera, &c., and afterwards commencing the survey of the great city of Jaina temples at Palitana. The season 1887–88, and the early part of the next were spent at Bijapur, a complete survey of the Muhammadan architecture being made there. On this important survey Mr. Cousens prepared a careful series of notes, printed as a selection from the Records of the Bombay Government.† The early months of 1889 were again devoted to Palitana. The season 1889–90 was spent almost entirely in completing the examination of the Gaikwar's districts in Northern Gujarat; the field season was completed by a survey of the newly discovered caves at Nadsur and Karsambla, on which Mr. Cousens has prepared a separate report,‡ and last season 1890–91 was devoted to a survey of the Hemadpanti and other remains in the Ahmadnagar and Nasik districts.

The survey drawings being only pencilled in the field, the whole of the rainy seasons are occupied in inking and preparing them for photolithography, writing up the notes, &c., and this being a slow work with so small a staff, it has of necessity gradually fallen somewhat behind.

The famous fresco paintings on the walls of the Buddhist caves at Ajanta had been copied by Major R. Gill at the expense of the East India Company. The canvasses were exhibited in the Indian Court of the Sydenham Crystal Palace. There they were destroyed by fire in December 1866. No reproduction of them had been

* "The Antiquities of the Town of Dabhoi in Gujarat" by Jas. Burgess, LL.D., C.I.E., Director-General of the Archæological Survey of India, and Henry Cousens, M.R.A.S., of the Archæological Survey, Western India. Published by order of H.H. Mahârâja Sayajirav Gaikwar, G.C.S.I., of Baroda. (Edinburgh: G. Waterston and Sons, 1888).

† No. CCXLV. New Series: "Notes on the Buildings and other Antiquarian "Remains at Bijapur, by Henry Cousens, M.R.A.S., Archæological Survey, Western "India; with translations of the Inscriptions by E. Rehatsek, Esq., M.C.E." (Bombay, Government Central Press, 1890.)

‡ Printed as a Memorandum (No. 12) of the Archæological Survey (Bombay Government Central Press, 1890). Reviewed, Jour. R. I. B. Arch. VII., 436.

attempted beyond a few outline drawings on a very small scale in Mrs. Speir's "Ancient India." Dr. Burgess applied to the Government of Bombay to endeavour to have what remained of these frescoes copied again before they should entirely disappear under the destructive agencies at work. This led to a grant of Rs. 5,000 per annum being sanctioned by the Government of India for the purpose, and Mr. John Griffiths of the Bombay School of Art was appointed to take charge of the work in 1872. The copying went on at intervals from this date till 1885, when it was brought to a close. The copies were sent home to the India Office, and transferred to South Kensington, where again, most unfortunately, a number of these important paintings were destroyed by a fire. Photographs of the copies were taken at the Bombay School of Art, and recently steps have been taken to publish these most interesting and instructive remains of ancient art. Of their artistic value, Mr. Griffiths writes in his Report:—

"The condition of mind which originated and executed these paintings at Ajanta, must have been very similar to that which produced the early Italian paintings of the 14th century, as we find much that is common to both. Little attention paid to the science of art—a general crowding of figures into a subject, regard being had more to the truthful rendering of a story rather than a beautiful rendering of it; not that they discarded beauty, but they did not make it the primary motive for representation. There is a want of aerial prospective, the parts are delicately shaded, not forced by light and shade, giving the whole a look of flatness, a quality to be desired in mural decoration.

"Whoever were the authors of these paintings, they must have constantly mixed with the world. Scenes of everyday life, such as preparing food, carrying water, buying and selling, processions, hunting scenes, elephant fights, men and women engaged in singing, dancing, and playing on musical instruments. Many are most gracefully, and all are most graphically depicted upon these walls; and they could only have been done by men who were constant spectators of such scenes; by men of keen observation and retentive memories. The artists certainly could not have observed one of the ten commandments which Buddha imposed on his disciples, viz,, to abstain from public spectacles. In every example that has come under my observation, the action of the hands is admirable, and unmistakeably conveys the particular expression the artist intended."*

Southern India.—In consequence of representations made by the President of the Oriental Congress of 1874, the Secretary of State addressed the Madras Government on the subject of appointing an

* The frescoes are described in detail in "Notes on the Bauddha Rock Temples of Ajanta, their Paintings and Sculptures (illustrated), &c." by J. Burgess. (Bombay: Government Central Press, 1879); *see also* Mr. Fergusson's paper on the portrait of Chosroes II. at Ajanta, in Jour. R. As. Soc. 1879, pp. 155 ff.

Archæological Survey of Southern India. Delays, however, intervened, and it was not till the Governorship of Mr. Adam (1881) that it was decided to organise a survey. The Madras Government then deputed Mr. R. Sewell to prepare lists of all the known monumental antiquities and inscriptions in the Southern Presidency in order to prepare the way for a detailed survey. Mr. Sewell commenced by issuing a circular asking for the co-operation of a large number of officials and private gentlemen both European and Native. Of these circulars 7,500 were issued. Much correspondence resulted, and Mr. Sewell consulted all the available literature on the subject. His object was not only to produce lists of antiquities for each district for the archæological surveyor, but also to furnish general information for the guidance of residents in Southern India who might care to join in the work of historical research. The Madras lists were published in 1882.* They were drawn up according to districts, and to each district list was prefixed a short outline of the history and antiquarian interest attaching thereto, the whole forming a volume of over 300 pages.

In 1875, Mr. Sewell, when stationed at Bejwada in the Kistna District, had been entrusted by Government with a grant of Rs. 1,000, to enable him to explore at Amaravati, Bejwada, Undavilli, and other places. Bejwada is a place of considerable antiquity, once the capital city of the small Kingdom of Vengi, and afterwards one of the chief towns of the eastern Chalukyas. The town is surrounded with granite hills honeycombed with the rock-cut memorials of ancient religious fervour, and stands on alluvial soil under which, whenever disturbed, appear the vestiges of past greatness, statues, and walls, and sculptures of old temples long since fallen, and now lying buried under many feet of river silt. Opposite, across the river, is the large four-storied temple of Undavilli, hewn in the solid rock, while almost every village has its especial relics of the past, Buddhist or Brahmanical. Here and there are the remains of the circular *stupas*, which the followers of the great Reformer erected over relics, either of himself or of his principal disciples; and 17 miles westward on the south bank of the river, lie the remains of the most

* Archæological Survey of Southern India. Lists of antiquarian remains in the Presidency of Madras. Compiled under the order of Government by Robert Sewell. Madras (E. Keys), 1882.

magnificent Buddhist monument in all India—the Amravati Tope.* Here Mr. Sewell set to work in 1877, and during the summer and autumn of that year, unearthed a large number of marbles which he closely described in his report.†

In 1879 Mr. Sewell went home on sick leave, and the following year the Duke of Buckingham, Governor of Madras, paid a visit to the spot and directed the district collector to complete the excavation of the tope, at a cost not exceeding Rs. 1,000. But, as Lord Hartington pointedly remarked in a despatch on the subject, the collector's special qualifications as an archæologist were unknown, the promised services of a Public Works officer to help him were not vouchsafed, and the general result was to convert the site of the tope into a large pit about 75 yards in diameter, to disarrange the stones and débris, and so destroy the chance of getting any idea of its size or structural arrangements.‡ Dr. Burgess is of opinion, however, that this once splendid monument had been destroyed perhaps more than once before, and that many of the beautiful slabs must have been used even within the last 65 years to burn into lime, or to repair miserable Svămi temples, and similar buildings. There are indications also of a great flood having first destroyed, or at least greatly injured, the stupa, possibly drowned many of its priests and worshippers and led to its falling into rapid decay, after which it was reconstructed after some rough manner.

On Mr. Adam's sudden death, Mr. (now Sir) M. E. Grant Duff became Governor, and in November 1881, the superintendence of the Madras Archæological Survey was also entrusted to Dr. Burgess. His first season was devoted to the survey of the remains round Bejwada, the Amaravati and Jaggayyapeta stupas, the Jaugada and Dhauli inscriptions of Asoka, and a visit to the Khandagiri and Udayagiri caves, taking facsimiles of all the inscriptions.

The season of 1882-83, besides the official work and direction of the Bombay Survey, was largely devoted, along with Mr. A. Rea, to the

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* Colonel Mackenzie and his assistants made careful drawings and plans in 1816 of this great monument, and Sir Walter Elliot excavated a large number of sculptures, now at the British Museum. The Stupa and its known sculptures were described fully in the second part of Fergusson's Tree and Serpent Worship.

† Report on the Amaravati Tope, and Excavations on its Site in 1877, by Robert Sewell. Printed by order of the Secretary of State for India in Council, 1880.

‡ Burgess's Notes on the Amaravati Stupa. Printed by order of Government, Madras: E. Keys. 1882.

examination of antiquities in the Madura district, and a very complete survey of the great temple of Ramesvaram which occupied the staff till the end of the season. In 1883 Mr. Rea surveyed in detail the monolithic remains, caves, and temples at Mamallapuram. Early in 1884 Dr. Burgess paid a visit to the shrine of Sri Sailam, on a remote hill top of the Nallamalai range, which had been only seen by one or two forest officers since it was visited by Colonel Colin Mackenzie just ninety years previously. This place he has identified with the Po-lo-yu monastery of Fa Hian, the Po-lo-mo-ki-li of Hwen Thsang, which had previously baffled all attempts at identification.

In 1884 Mr. Rea was chiefly engaged on the extensive remains of the old Hindu capital at Hampe or Bijyanagar; in 1885 he made an extensive survey of the old Pallava temples at Kanchipuram, and in the cold season 1885-86 he made a long tour from Gooty through the Anantapur and Bellari districts to Harihar and back, surveying numerous remains on the route. The survey at Mamallapuram was completed next season, and the fine temple at Vellur and others in the district examined. In June 1887 Mr. Rea made some remarkably successful excavations at Pallavaram, of prehistoric graves containing earthenware coffins, some of which he removed entire to the Madras Museum.* During the following dry season, he made a tour through Nellur and part of the Kistna districts, during which he excavated several mounds and discovered the remains of several Buddhist stupas; and during the season of 1888-89, he followed this up by a tour in the Godavari and in parts of the Kistna district previously unvisited, discovering some very interesting remains, such as an ancient structural Buddhist Chaitya at Chezarla and examining a group of caves and stupas at Guntupalle in the Godavari district.† In 1889-90 and 1890-91 the southern districts of the Madras Presidency were under survey by Mr. Rea and his native draftsmen. During these tours much valuable information and numerous carefully

* Jour. Asiat. Soc., Bengal, LVII., p. 48, and Madras G.O., 12th August 1887, No. 1135. Mr. Rea has also contributed an interesting paper on "Methods of Archæological Excavation in India," to the Journal of the Royal Asiatic Society for 1890, p. 183.

† Madras G.O., 30th April, No. 382; 29th May, No. 462, &c., and R. Instit. Brit. Architects Journal, November 1889, p. 58.

measured plans and detail drawings have been accumulated, as detailed in Mr. Rea's progress reports to the Madras Government.*

Dr. Burgess's report on the Amravati and Jaggayapeta Stupas appeared in 1887.† It contained the results of the examination and further excavations made by him of the remains in December 1881 and early part of 1882, soon after the excavation of the site by orders of the Madras Government, with photographs of the sculptures, taken in 1884, after their removal to Madras. Mr. Fergusson had offered to assist Mr. Burgess in the preparation of the work, but this offer was unfortunately cut short by Mr. Fergusson's death, an event which was nothing less than calamitous, so far as Indian archæology was concerned.

James Fergusson (1808–86) was an enthusiastic devotee of art, more especially in its relation to architecture, and he had published a large number of artistic and scientific works, the more conspicuous among which are "Tree and Serpent Worship" (1868) and "History of Architecture" (1855). But besides the former of these two, he published numerous other works relating to Indian archæology, such as "Illustrations of the Rock-Cut Temples" (1845), followed by "Picturesque Illustrations of Ancient Architecture in Hindustan." In 1859, he edited Captain Hart's "Illustrations of the principal Muhammadan buildings of Bijapur," and in 1866 supplied "Architectural Notes" to Mr. Hope's descriptions of Gujarat, in a work entitled "Architecture at Ahmadabad," doing a like service for Meadows Taylor's two volumes published in the same year—one on Bijapur, the other on Dharwar and Mysore. The beautiful book on "Tree and Serpent Worship" referred to above, appeared in 1868, and a second edition followed in 1873, while "Archæology in India," produced in 1884, was a volume mainly elicited by strictures, but which contains important elucidations of the earliest Hindu

* These reports contain a full diary of the work done and drawings made, with numerous notes. See, for example, Madras, G.O., 13th April 1885, No. 882; 29th Sept., No. 2,300; 15th Oct., No. 2,440; 5th Dec., No. 2,830; 9th Feb. 1886, No. 281; 22nd April, No. 835; 25th Feb. 1887, No. 286; 20th April, No. 583; 11th June, No. 803; 21st Sept. No. 1,361; 4th October, No. 1415; 14th July 1888, No. 703; 11th Sept., No. 896; 4th March 1889, No. 219, &c.

† Archæological Survey of Southern India. The Buddhist Stupas of Amravati and Jaggayyapeta. . . . . Surveyed in 1882 by Jas. Burgess, LL.D., C.I.E., Director-General of the Archæological Survey of India. With translations of the Asoka inscriptions at Jaugada and Dhauli. By Georg Bühler, Ph.D., C.I.E., London (Trübner), 1887.

forms of architecture. His occasional contributions to the transactions of societies are too numerous to be specified individually, and it is not too much to say that his labours, during a long series of years, on behalf of Indian archæology, were simply invaluable.*

Dr. Burgess retired in June 1889 from the post of Director-General of the Archæological Survey. His keen interest in Indian archæology and early training as an architect had led to his being recommended to the Secretary of State by Mr. Fergusson for the task of completing a survey of the cave temples. In January 1871 Dr. Burgess produced his monograph on the Elephanta caves, the first work published in India dealing with cave architecture on comparative principles, and fixing the approximate date of the caves. While making researches in monumental archæology in Western India, he did not neglect other branches, as shown in the pages of the "Indian Antiquary," started in 1872 and conducted by him for 13 years. To epigraphy, in particular, special attention was devoted in this journal, and facsimiles, in preference to eye copies, of some hundreds of inscriptions were published in its pages The collotype reproductions of the Girnar inscriptions in his second report formed the basis of M. Senart's elaborate work on the "Inscriptions of Piyadasi." After carrying on the Archæological Survey of Western India for nearly eight years, the superintendence of that of Southern India was added to Dr. Burgess's charge in November 1881, and early in 1886 he was appointed Director-General for the whole of India. In 1885 the value of his services in the Survey had been recognised by the Order of C.I.E. being conferred upon him. He had been elected an honorary LL.D. of Edinburgh University in 1881.

In May 1889, the general position of the Archæological Survey all over India was re-considered. The reports then awaiting editing and publication comprised two reports by Dr. Führer and Mr. E. W. Smith, dealing with places in the North-Western Provinces, three reports by Mr. Rodgers on the Punjab, four by Mr. Rea on Kanchi

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* A careful and sympathetic notice of the late Mr. James Fergusson from the pen of Sir Frederic Goldsmid, will be found at page 113 of the "Proceedings" of the Royal Geographical Society for 1886; and another by Mr. W. H. White, F.R.I.B.A., in the Annual Report of the Royal Asiatic Society for 1886, pp. xxiv—xxxix. A just tribute is paid to his services in the Quarterly Review for July 1889, in an article on "Ancient India"; *see also* Journal, Royal Institute of British Architects, August 1889, p. 356.

or Conjiveram, Mamallapuram, Bijayanagar or Hampe, Rameswaram and Madura, various reports by Dr. Burgess on Ahmadabad, Broach, Dholka, Champaner, and Mehmudabad and Sojali, and by Mr. Cousens on the Chalukya architecture of Dharwar and Belgaum, the Musalman Architecture of Bijapur, and (for the Gaikwar) on the ancient architecture of Northern Gujrat. It was estimated that these materials would fill 12 volumes, and arrangements were made for Dr. Burgess, on his retiring from the Service, to continue the work of editing and supervising the publication of the volumes at home. The archæological staff was then reduced to the following:—

Mr. H. Cousens, C.E., Superintendent of the Archæological Survey, Western India.

Mr. A. Rea, Architect, Superintendent of the Archæological Survey, Southern India.

Dr. E. Hultzsch, Epigraphist, Southern India.

Dr. A. Führer, for general Antiquarian and Epigraphical Research in the North Western Provinces.

Mr. E. W. Smith, Architectural Assistant to Dr. Führer.

There are now three parties, one under Mr. Rea, another under Mr. Cousens, and a third under Dr. Führer and Mr. Smith, each being provided with a small staff of native draftsmen, Dr. Hultzsch continuing his epigraphical researches in Madras.

Among recent literature on Indian archæology mention may be made of an excellent paper on "Ancient India," more particularly with reference to its antiquarian remains, as described in the principal official reports of the last 20 years, which will be found in the "Quarterly Review" for July 1889, Vol. 169. A paper of a more general character, entitled "The History of Archæology in India," formed the subject of an interesting lecture by Mr. James Gibbs, C.S.I., C.I.E., delivered before the Society of Arts on the 2nd April 1886 (Journal XXXIV., p. 555). A French writer, too, Dr. Gustave Le Bon, has produced an interesting volume, entitled, "Les Civilisations de l'Inde," and issued by Firmin-Didot et Cie., in Paris. The book, which is profusely illustrated with lithographs and chromo-lithographs, is the fruit of an archæological mission through India, with which Dr. Le Bon was charged by the French Minister of Instruction.

In the "Journal of Indian Art" (W. Griggs, Peckham) occasionial papers on Indian archæology have appeared, among which the following may be instanced:—In Vol. I., No. 8, p. 61, and

No. 10, p. 76, "Decorations of the Taj Mahall, Agra," by Sir George Birdwood; in Vol. II., No. 17, "Chalukyan Temples," by H. Cousens, with five characteristic illustrations; No. 19, p. 17, "Mosque of Vazir Ali ad-din Khan, at Lahore," by J. L. Kipling, C.I.E., with four coloured plates; in Vol. III., No. 28, p. 23, "Ancient Chalukyan Stone Carving," by H. Cousens, with two plates; No. 32, p. 49, review and analysis, by Dr. Burgess, of Colonel Jacob's "Jaypur Portfolios of Architectural Details," with 15 plates; and in Vol. IV., No. 34, p. 13, "Detail Drawings," from Urchha, Fathepur Sikri, and Mathura, by Ed. W. Smith, with four plates.

Colonel S. S. Jacob, C.I.E., State Engineer at Jaypur, has, in 1890, brought out, under the patronage of the Maharaja, a series of six magnificent portfolios, containing 374 plates (each 22 inches by 15) of architectural details from buildings in Upper India. This promises to be only half the complete work. It is published by W. Griggs, Peckham, and Bernard Quaritch, Piccadilly.

As an application of the architectural details drawn for the archæological surveys under Dr. Burgess's direction, it may be noted that the Government of India has ordered the reproduction of a selection of the drawings of examples of decorative details, under the title of a "Technical Art Series." These plates are distributed, at a low charge, to schools of art, technical workmen, and others, as specimens of purely antique native art. With the first series short notes are also issued, prepared by Dr. Burgess, explanatory of their origin, age, material, &c. The second series is now in course of issue.

Burma.—In Burma, during the last ten years, strenuous efforts have been made by Dr. Forchhammer, an antiquarian of eminence, to collect and render accessible the rich Pali and Burmese literature of the province and the written records of the Talaings, Shans, Kathes, and other nations and tribes inhabiting Burma and the bordering countries. A beginning was made with the formation of a library to contain all printed books and pamphlets on Buddhism and Pali, the religions of India, and the languages which record its sacred and secular writings, and a nucleus was secured in the shape of the valuable library of the late Professor Childers. Successful efforts were also made to secure remains of the old Talaing literature which had survived the wholesale destruction ordered by Alompra, the Burmese conqueror of the Talaings, and which were hidden and rotting away in the caves on the Salwen

and Attaran rivers. A number of Siamese and Cambodian manuscripts were also found in the same localities, and the collection was augmented in 1886–87 by a large number of splendid manuscripts received from Mandalay and by native gifts. These have been deposited in the manuscript department of the Bernard Free Library and the collection of Pali, Burmese, Talaing, Siamese, Cambodian, and Sanskrit (in Burmese characters) manuscripts is probably the largest of its kind in existence. During the last ten years ample material for a history of Pali-Burmese and Talaing literature has been gathered.

Archæological research has been carried on jointly with the search and collection of manuscripts. All parts of Lower Burma have been visited, except the upper reaches of the Kaladan and Mayu river, where important finds may be expected. The region south of Moulmein, down to Tavoy and Mergui, and a few places at the mouth of the Bassein river, and in the eastern portion of the Prome district remain to be examined. In 1887, Dr. Forchhammer's Burmese assistant visited Amarapura and Ava, chiefly with the view to secure prints of the many inscriptions. These, especially those which a century ago were moved to Ava by the Burmese king Bodawpara from all parts of Burma and newly conquered territories. About 500 of these lithic monuments await examination. A large number of inscriptions from various localities have been copied out, and a tabular list, as prescribed by the Government of India, has been prepared of the Arakan, Thayetmyo, Prome, Henzada, Bassein, and Thongwa districts.

Unfortunately, Dr. Forchhammer fell ill, and died in April 1890, before he had had time to publish all the materials he had collected. The reports actually issued are the following :—

List of objects of antiquarian interest in Lower Burma.
I. Arakan. 1891.

Arakan I. Mahamuni Pagoda.
II. Mrohaung.
III. Launggyet, Minbya, Urittaung, Akyab, and Sandoway.

Pagan. I. Kyaukku Temple.

Lists of objects of antiquarian and archæological interest in British Burma, Rangoon. 8vo. 1884.

Notes on the Shwe Dagon pagoda. Rangoon, 1883.

The Chief Commissioner of Burma has been asked to submit a full programme of the archæological work which has yet to be undertaken in Burma, together with his opinion as to the desirableness of starting a survey there upon the lines adopted in India proper.

In connexion with archæological and literary research, mention may be made of an important work on the geography of the countries adjacent to North-Western India which during the last fifteen years has been under compilation in England. Major H. G. Raverty, known for his translations of Afghan and other Oriental works, as well as for his historical investigation in connexion with Asiatic countries has been engaged in translating, annotating and amplifying with the fruit of his own personal observations a voluminous Oriental manuscript of an unique character. Two copies of this manuscript have come into Major Raverty's possession, but the author's name will not be divulged by the Major till the last chapter of his book is reached.

Major Raverty's work is entitled, "Notes on Afghanistan and " part of Baluchistan, geographical, ethnographical, and historical, " extracted from the writings of little known Afghan and Tajzik " historians, geographers, and genealogists; the histories of the " Ghuris, the Turk Sovereigns of the Dihli Kingdom, the Mughal " Sovereigns of the House of Timur and other Muhammadan " chronicles, and from personal observations."

The backbone of the work, so to speak, is supplied by the translation of the manuscript, which is indicated throughout by inverted commas, but the additional matter contributed by Major Raverty, whether as comment or notes, is quite as voluminous as the original text. Although the native author's name is not given, we are told a good deal about him. He was a man of Mogul descent, of good family and superior education, and possessed a great taste for geographical knowledge. He says he undertook the series of journeys which he narrates for the purpose of describing the appearance and political condition of the countries adjacent to Delhi on the north and north-west, because he found that the historians of his day, even if they possessed such information, invariably omitted it from their records. He was in the prime of life about the time that Ahmad Shah overthrew the Marathas at the battle of Panipat (1761), and subsequently, when Hindustan was in an utter state of disorder, culminating in the blinding of the old king Shah Alam, the

author set out on his wanderings, which were spread over eight or nine years, and the account of which he completed in 1790—91. The date of his death is not known apparently, but he was acquainted with the names of Warren Hastings and the Marquis Wellesley, to whom he was presented, if indeed he was not personally well-known to them.

The manner in which this native traveller explored the various routes which he describes is not exactly stated, but he appears to have used a compass, as he gives bearings and distances, and where these have been tested on recent occasions by our troops and surveyors they have been generally found to be very accurate. He evidently lost no opportunity of accompanying the inhabitants and merchants of these parts in their journeys to and fro, and of getting them to aid him in his objects. He would often make a stay of some duration in a particular locality until he had succeeded in learning all that was possible about it, not unfrequently making acquaintance with the head men and priests. For instance, when his travels had brought him up to the remote valley of Chitral on the extreme north-west frontier of India, he was fortunate enough to fall in with a kindred spirit in Shah Riza of Drush, the Badshah or chief of Kashkar and Chitral, who not only gave the author every facility for exploring those regions, but even personally accompanied him on foot for the purpose of thoroughly examining the various passes which lead over the huge mountain range of the Hindu Kush into the valley of the Oxus River.

The manuscript itself is in Persian, though portions here and there forming, not improbably, the substance of oral information given to the author, are in the Pushtu or Afghan tongue. It is translated verbatim for the most part by Major Raverty, who has enriched it with innumerable notes and comments, and with collateral information obtained from Oriental historians and European translators and critics.

Inscriptions and Coins.

Indian inscriptions have at all times attracted the attention of scholars. The Hindus in their literature have scarcely produced any works of a historical character, though family legends, local traditions, and Puranic or mythological tales are common enough. Fortunately, this want is largely compensated for by numerous contemporary records in the shape of inscriptions, forming the

title-deeds of grants and endowments made by kings and chiefs to temples and religious communities, some being on rocks, some on the pillars and walls of temples, and others engraved on plates of copper held together by rings to which is attached the seal of the reigning dynasty. In these inscriptions lies the hope of filling up the many lacunæ in Indian history, and we find that Sir Charles Wilkins, General John Carnac, Sir John Shore, and others who rallied round Warren Hastings and Sir William Jones, to form the Asiatic Society of Bengal ninety years ago, fully recognised this, and at once began to collect and investigate the contents of inscriptions.* Colonel Colin Mackenzie during the first years of the century did much to collect inscriptions, especially in Southern India, where they are very numerous, and is said to have prepared copies of no less than 8,076. Francis Buchanan (Hamilton) also collected many inscriptions. During his long residence in India, Sir Walter Elliot spared no pains in collecting impressions of copper plate grants, and transcriptions of stone tablet inscriptions, and by means of them was able to establish the chronology of the great Chalukya dynasty of the Kanarese and Maratha countries, which flourished from the 5th to the 12th Centuries. Others, such as Tod, Prinsep, Le Grand Jacob, Bhau Daji, and Cunningham showed like activity in collecting, but as Lassen truly remarks† it was the zeal and thoughtfulness of individuals, rather than the care of the Government, to which the knowledge and preservation of these ancient monuments of the country were due.

However, in 1851 the Bombay Cave Temple Commission, appointed to carry out the object of the despatches of the Court of Directors,‡ obtained the appointment of Lieut. Brett to copy and take impressions of the inscriptions; and reduced lithographs and translations were published by the Rev. Dr. Stevenson in the Journal of the Bombay branch of the Royal Asiatic Society. Early in 1856, the same Commission recommended the publication under Government, of fac-similes or copies with decipherments and

* Pali, Sanskrit, and old Canarese inscriptions from the Bombay Presidency, and parts of the Madras Presidency and Maisur. By J. F. Fleet and Jas. Burgess, London (Eyre and Spottiswoode). 1878.

† Alterthumskunde, II., 42.

‡ No. 15 of 29th May 1844, No. 1, 27th January 1847, No. 24, 29th September 1847, and No. 13 of 4th May 1853, and Resolution of Bombay Government of 31st July 1848. (No. 2805.)

translations of ancient inscriptions, the whole to form a complete *Corpus Inscriptionum.* This led to the appointment of Vishnu Sastri Bapat as Pandit, who in the course of five years copied and translated into Marathi some 88 Pali and Sanskrit inscriptions, but none of them were published, and the death of the Pandit, the Mutiny, and the transfer of the Government of India to the Crown interrupted the work.

About 1865 the Government began to take a keener interest in the matter, and a photographic collection of 149 inscriptions on copper plates and stone tablets, taken in Mysore by Lieut.-Col. H. Dixon, 22nd Regiment, M.N.I., was printed by the Government of that State; while Mr. (now Sir Theodore C.) Hope issued a smaller collection of inscriptions in Dharwar and Mysore. A few years later the Duke of Argyll, then Secretary of State for India, forwarded a scheme to the Bombay Government, for the collection and preservation of ancient Kanarese inscriptions, but it was not till the starting of the "Indian Antiquary" in 1872, and the organization of the Archæological Survey of Western India in 1874 that opportunity occurred for obtaining fac-similes of these and similar records. A grant was made by Government to the "Indian Antiquary," and this proved of great service by enabling a large number of inscriptions to be photo-lithographed in Vols. III. to XIII., those in Vols. VI. to XIII. being largely selected from Sir Walter Elliot's collection.

In 1878, under the sanction of the Secretary of State for India, a volume was produced by Messrs. Fleet and Burgess, containing, as a basis, the collections of Colonel Dixon and by Dr. Pigou (which had been included in Sir T. C. Hope's "Inscriptions in Dharwar and Mysore"). These were supplemented by photographs taken by, and lithographs from *estampages* and rubbings made by the Archæological Survey of Western India, and Mr. Fleet, besides fac-similes of other grants. But these were far from embracing even nearly all the inscriptions from Western India and the Dekhan at present available, for in the India Office Library, in the Royal Asiatic Society, in the Bombay Asiatic Society, in the British Museum, and in private hands both in India and in Europe, there are a considerable number of copper-plate grants which, if published in fac-simile, would fill up many lacunæ, and supply important dates.

To the volume on Pali, Sanskrit, and old Canarese inscriptions is prefixed an important introductory chapter on Indian inscriptions, the substance of which I have reproduced in the above sketch.

In 1877 General Cunningham brought out the first volume of the "Corpus Inscriptionum Indicarum," containing the inscriptions of Asoka. These edicts are the earliest Indian inscriptions yet discovered, and are of two distinct classes, generally known as rock inscriptions and pillar inscriptions, to which may be added a few cave inscriptions in Behar and Orissa. The six rock inscriptions present six different texts of the same series of edicts, published by Asoka in 253 and 251 B.C. They are found at far-distant places: three being on the extreme northern, two on the eastern, and one on the western borders of India, thus showing the wide extent of Asoka's rule, as well as the great care which he took about the promulgation of his edicts in remote parts of his dominions. Asoka was the third prince of the Maurya dynasty, and the grandson of Chandragupta, who was identified by Sir William Jones with Sandrakoptos, the contemporary of Seleukos Nikator. The edicts themselves are fourteen in number, and were summarised by James Prinsep.* Their main object, as expounded by Wilson, appears to be the exaltation of moral obligations over all ceremonial practices, over a religion of rites; the enjoining, in preference to the sacrifice of animals, obedience to parents, affection for children, friends, and dependents, reverence for elders, Sramans, and Brahmans, universal benevolence and unreserved toleration. Wilson concludes his account with the following words: "The edicts may be taken as historical "evidence that Buddhism was not yet fully established, and that "Priyadasi or Asoka was desirous of keeping peace between it and "its predecessor by inculcating social duties and universal toleration "in place of either ritual or dogma."

The inscriptions of Asoka are also invaluable for the study of the vernacular languages of India, as they furnish several undoubted texts of the common language of the people in the 3rd Century B.C. This spoken language was essentially the same in the region lying between the Himalayas and the Vindhyas, from the banks of the Indus to the mouths of the Ganges. The written character is two-fold—one called Ariano-Pali, and read from right to left, which is found on the Shahbáz-garhi rocks, in the Yusufzai district, on the extreme north-west, and on three large boulders at Mansahra, in the Hazara district, and which is also found on the coins of the Greek and Indo-Scythian princes of Ariana; the other, Indo-Pali,

* Journal, Bengal Asiatic Society, VII., 220.

read from left to right, which is confined to the coins of Pantaleon and Agathokles, who reigned beyond the Indus, but which is the common character of all the other texts of the inscriptions, as well as of all the donative inscriptions of the Sanchi and Bharhut stupas. The distinctive peculiarities of these two alphabets are carefully discussed by General Cunningham, and the transcripts of most of the edicts with the translations are given in full in his work.*

In 1883, Mr. J. F. Fleet, C.I.E., was appointed Epigraphist,† with the primary object of preparing Volume III. of the "Corpus Inscriptionum Indicarum," that was to contain the inscriptions of the early Gupta kings. The Gupta volume was completed by Mr. Fleet in 1887, and published the following year in Calcutta. A careful study of the inscriptions enabled Mr. Fleet to fix the period of the early Gupta supremacy, and also to establish a starting-point from which to work back in developing the Indo-Scythian history. Moreover, through fixing, for the first time, the date of Mihirakula, who, as we learn from the writings of the Chinese pilgrim, Hwen Thsang, played a leading part in early Indian history, Mr. Fleet has furnished the means of adjusting the chronology before and after him of the early history of Kashmir, and of testing the accuracy of the Chinese accounts of the same early period.

The principal records in the volume are those of the early Guptas themselves from A.D. 401 to 466, and next, the records of a feudatory family, the Parivrajaka Maharajas, which prove that, though the direct line of the early Gupta dynasty itself may have become extinct, the Gupta dominion still continued, and the name of the Gupta kings was still recognised as a power down to A.D. 528. The person who accomplished the final extinction seems to have been the great king Mihirakula, of Sakala, in the Punjab, and subsequently of Kashmir, whose career in India is so graphically described by Hwen Thsang. Next come the inscriptions of the

* Corpus Inscriptionum Indicarum, Vol. I., Inscriptions of Asoka. Prepared by General Cunningham, C.S.I., Calcutta, 1877. The Mansahra inscriptions were discovered subsequently, as well as the Rampurwa pillar. A valuable discussion of these inscriptions has been published, in two volumes, under the title, "Les Incriptions de Piyadasi, par E. Senart, Mem. de l'Inst." (Paris, 1881-86); and detached papers on them by Prof. G. Bühler, LL.D., C.I.E., have appeared in the "Zeitschrift der Deutsch. Morgenländ. Gesellschaft," at different dates.

† On the 17th January 1883. He held the appointment for 3½ years, until the 1st June 1886. In August 1881, Dr. Burgess had prepared a "Memorandum on the Collection and Publication of Indian Historical Inscriptions," which he submitted to the Secretary of State, recommending this appointment.

kings of Valabhi, ranging from 426 to 766, after which occur inscriptions of various families of minor importance. The exact chronological place of the Gupta era, a historical question which has been discussed by scholars for forty years, is ascribed by Mr. Fleet, after a learned and exhaustive discussion, to A.D. 319–320.

Lists of inscriptions in Southern India were drawn up by Mr. R. Sewell, and these, together with a sketch of the dynasties of Southern India, were published by Government in 1884.*

In 1886, at the suggestion of Dr. Burgess, a circular letter was issued by the Government of India to the local governments, to afford all assistance to the surveyors in framing lists of existing inscriptions. The same year saw the first attempt towards the elucidation of the Tamil inscriptions of Southern India, when Mr. Burgess produced a work on Tamil and Sanskrit inscriptions.† The first batch of notes and inscriptions had been collected in the Madura district in 1883. The second part contains 56 Tamil inscriptions, collected at the great temple of Ramesvaram and elsewhere, in the Ramnad Zamindari, and the third part, a miscellaneous collection of both Tamil and Sanskrit inscriptions from various parts of the Madras Presidency. In the same year (1886) Dr. E. Hultzsch, a German scholar, versed in the Sanskrit, Pali, and Dravidian languages, was appointed Epigraphist to the Government of Madras, and during that and the following year he collected over 150 Tamil and Sanskrit inscriptions from stone and copper-plate edicts at Mamallapuram, Kanchipuram, in the North Arcot district, and other parts of the Madras Presidency.‡

With the object of promoting still further the study of Indian inscriptions, a quarterly publication entitled "Epigraphia Indica and Archæological Survey Record" was started under the editorship of Dr. Burgess in October 1888. A grant of Rs. 6,000 (afterwards reduced to Rs. 4,000) was made to this undertaking by the Government of India. Of this publication, eight parts (456

* Archæological Survey of Southern India, Vol. II.—Lists of inscriptions and sketch of the dynasties of Southern India. Compiled under the orders of Government by Robert Sewell. Madras: E. Keys, 1884.

† Archæological Survey of Southern India, Vol. IV.—Tamil and Sanskrit inscriptions, with some notes on village antiquities, collected chiefly in the south of the Madras Presidency. By James Burgess. With translations by S. M. Natesa Sastri, Pandit. Madras: E. Keys, 1886.

‡ South Indian inscriptions, Tamil and Sanskrit, edited and translated by E. Hultzsch, Ph.D., Government Epigraphist, Archæological Survey of Southern India. Madras (Higginbotham & Co.), 1890.

pages) have been published, containing a large number of very important inscriptions for the early history of India, and translated by such accomplished orientalists as Professors G. Bühler, LL.D., C.I.E., of Vienna, F. Kielhorn, Ph.D., C.I.E., of Göttingen, Prof. J. Eggeling, Ph.D., of Edinburgh, &c., whose names are a sufficient guarantee for the authority of their versions and comments. Facsimiles of the more important epigraphs are also issued in the work, which, if it is continued, will form an important supplement to, or rather a substitute for the *Corpus Inscriptionum Indicarum.*

Among the more important inscriptions for the early history of India contained in this first volume of the "Epigraphia Indica," now all but complete, are—the recently discovered twelfth edict of Asoka from Shahbazgarhi; an early Prakrit copper-plate grant of the Pallava king Sivaskandavarman; an inscription from Lakkha Mandal in the Himalayas, of about the sixth century, containing the genealogy of the early kings of Singhapura; two long inscriptions of the beginning of the ninth century from Baijnath in Kangra; eight from Khajuraho, and other Chandella records; the great Siyadoni inscription discovered by Dr. Burgess; a new record of Toramana from the Panjab; a large number of short but important Jaina inscriptions excavated from the Kankali Tila at Mathura; and numerous others of great historic interest.

Another valuable aid in the elucidation of Indian history is afforded by coins, which enable one to trace the chronology and sequence of ancient dynasties. Much light has been thrown on this branch of antiquarian knowledge by the researches of Sir Walter Elliot, who many years ago supplied a review on the coins of Southern India.* In regard to the coins of Northern India, the labours of James Prinsep, Wilson, Cunningham, and Edward Thomas have contributed valuable information; and Mr. Thomas's re-issue of Marsden's "Numismata Orientalia" has been the means of bringing out some important papers on Indian coinage, chief among which may be mentioned Part I., published by Mr. Thomas himself in 1874, on ancient Indian weights and the origin of a currency in India: one (Vol. III., Part I.) by Lieutenant-General Sir Arthur P. Phayre, G.C.M.G., on the "Coins of Arakan, of Pegu, and of Burma," and another (Vol. III., Part II.) by Sir Walter Elliot on the "Coins of Southern India."

* Under the head of Numismatic Gleanings, in the "Madras Journal," XIX., p. 220, and XX., p. 75.

XVI.

THE GEOGRAPHICAL WORK OF THE INDIA OFFICE.

The foregoing chapters have dealt with the departments and agencies entrusted with the conduct of the actual operations in India and the collection of statistical facts on the spot. It now remains to devote a few pages to the department in England charged with the duty of advising the Secretary of State as to the control of these operations, and to the utilization of the information acquired.

The geographical work of the India Office consists of correspondence, reports, and general business relating to the following distinct branches:—

The Great Trigonometrical Survey.
The Topographical Surveys.
The Revenue Surveys.
The Marine Survey.
The Geological Survey.
The Archæological Surveys.
Meteorology.
Observatories and Instruments.
Utilisation of the Result of the Surveys.

The last-named head includes the organisation and arrangement of the map collection, consisting of both the old and the current maps, the keeping of the books of sales, loans and gifts of maps, the compilation of such maps as may be required in England, the preparation of catalogues and reports on the work, and the supply of geographical information. The organisation of the Geographical Department or Branch of the India Office may be said to date from the 14th September 1868, when its duties were placed tentatively in charge of Mr. Clements R. Markham, C.B., for the period of six months. Previously to that the survey reports had been sent home without covering letters, and the absence of any permanent responsible officer to receive, analyse, and arrange for general reference all geographical documents and maps had led Colonel H. L. Thuillier, the Surveyor-General, to make a representation to the Secretary of State, pointing out the inconvenience of the existing state of things

and the necessity for a better arrangement. Colonel Thuillier's views were favourably received; the six months' preliminary charge enabled Mr. Markham to get a good grip of the work, and with the experienced assistance of Mr. Trelawney Saunders much progress was made in sorting and arranging the maps. In July 1869 Mr. Saunders' appointment was made permanent as "Assistant in the Geographical Department" with a salary of 400*l.* per annum, and shortly afterward agents for the sale of maps were appointed, and a map mounter's services were secured to the Department.

The "Memoir on the Indian Surveys," the prototype of the present work, was produced by Mr. Markham in 1871. It contained a complete and succinct account of the operations under its various heads from the earliest period down to 1869, and the author's plan contemplated the publication of annual "abstracts" in continuation of the original Memoir, and arranged in the same form. During the following years, the Geographical Branch was re-inforced by the appointments of the present writer in 1872 and Mr. W. Ronson in 1873. The Moral and Material Progress Reports for 1871–2 and 1872–3, arranged on a better system, and supplying a fuller retrospect of past administration than previous reports, were prepared by Mr. Markham and received universal commendation. Mr. Markham also discovered and edited the journals and other papers of George Bogle, Warren Hastings's envoy to Tibet, and Mr. Thomas Manning, who travelled to Lhasa, and in the translation of the appendices and in the preparation of the maps to accompany the work the staff of the department gave useful aid. The Annual "Abstracts of Surveys" were also regularly prepared from year to year, those for 1869–70, 1870–71, 1871–2, and 1872–3 being written by Mr. Markham, and those for the succeeding years up to 1880 by the present writer. In 1876 a simplified catalogue of the maps on sale was compiled by Mr. Ronson. The want of such a catalogue had long been felt, and its handy formed alphabetical arrangement found to be a distinct convenience, greatly facilitating reference. During these years a general catalogue of all the original maps, plans, surveys, memoirs, field books, &c. in the Department was under preparation by Mr. Saunders, and was finally published in 1878. It was a laborious undertaking, and its successful completion reflected much credit on Mr. Saunders. Mr. Markham, Captain (now Colonel) H. R. Thuillier,* and Mr. F. B. Girdlestone had assisted

* The present Surveyor-General of India.

in the earlier stages of its preparation. Its object was to supply a catalogue of all the geographical documents in the India Office, and with the addition of the regular quarterly lists of maps since received from India this object may be still said to be secured. The enormous accession of new maps during the last fifteen years has, however, completely revolutionised the former condition of things, and an entire re-arrangement of the geographical collection of the India Office has now (1891) become necessary. The ideal organisation, did space permit, would be to have presses in and adjoining the map room sufficiently numerous to accommodate a copy of every map, old and new, for consultation and ready reference, with a reasonable margin of room in each press for future accessions. This would constitute the permanent collection. Space, however, is precious, and it will probably be necessary to effect some compromise which will enable those maps in most frequent demand to be stored within easy reach. The saleable and non-saleable stock, though also crowded, are conveniently arranged under reference numbers, and do not so urgently need additional accommodation. This re-arrangement of the collection will be a fitting opportunity for the complete revision of the general catalogue.*

In 1877, Mr. Markham's retirement from the public service naturally affected in a very marked manner the geographical business of the office. The Department or Branch was his own creation; for ten years he had watched over its growth, and his geographical talents, his energy, and the personal example with which he inspired the staff, had borne good fruit. A short sketch of the public services of this officer is here necessary.

Mr. Markham served in the navy for eight years, during which time he was employed in one of the Arctic Expeditions in search of Sir John Franklin. In July 1854 he was appointed to the Board of Control, and served in the Secret Department through the time of the Persian War and Indian Mutiny. From 1858 to 1862 he was in the Revenue Department, and it was during that period that he was deputed to South America for the purpose of collecting chinchona plants and seeds and introducing them into India.

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* During the last few years a useful series of catalogues of current maps of the different presidencies and provinces of India has been issued by the Surveyor-General of India. The opportunity has been taken to bind these different *fasciculi* together and reprint the work, with the addition of an index, for the use of the India Office and English readers. This catalogue, which will fulfil a much felt want, has been just published.

From July 1861 to August 1863 he acted as Private Secretary to Mr. Baring (now Lord Northbrook). A second visit was paid by Mr. Markham to India in 1865 for the purpose of inspecting and reporting upon the then existing chinchona plantations, on the best sites for new ones, and on the pearl fisheries. He served as Geographer to the Abyssinian Expedition in 1866, and was created a C.B. in 1872. It was during his service in the Public Works Department that Mr. Markham was entrusted with the charge of the geographical business of the India Office, and his tenure of this post was marked by many important reforms and services which he was chiefly or wholly instrumental in carrying out. One of his first labours was the preparation of the original "Memoir on the Indian Surveys," a work which had a good circulation, and which was translated into the French and Dutch languages. Mr. Markham always strongly advised the preparation of similar "Memoirs" for all the Departments of the India Office. The resumption of Marine Surveys (which had been wholly abandoned after the abolition of the Indian Navy) was strenuously advocated by Mr. Markham, and eventually sanctioned, and the creation of a central Meteorological Department for the purpose of collating and utilizing the scattered observations was another matter which he continued, and with eventual success, to press upon the attention of the Government. The General Catalogue of all the Geographical Records of the Department was begun by Mr. Markham, and continued and completed by Mr. Saunders. Another task entrusted to Mr. Markham about this time was the preparation of the Moral and Material Progress Statement required by Act of Parliament to be laid before Parliament. Mr. Grant Duff, who had obtained the introduction of the section in the Indian Councils Act,* providing for the report in question, and who was Under Secretary of State in 1872, was desirous that an interest should be aroused in Indian affairs by the annual presentation of a thoroughly readable document. The reports for 1871–2 and 1872–3 were great improvements on their predecessors and gained general approbation. The discovery of the journals and other papers of Mr. George Bogle, who was sent on a mission to Tibet by Warren Hastings, and of Mr. Manning, the only Englishman who ever visited Lhasa, was due to Mr. Markham's research, and the Secretary of State sanctioned their being printed and published at

* 21 & 22 Vict. cap. 106, sec. liii.

the Government expense. An admirable introduction was prefixed, giving an account of Tibetan geography and history, and the journals were annotated throughout by Mr. Markham.

On the retirement of Mr. Markham the geographical work was transferred to the Statistics and Commerce Department under Mr. H. Waterfield. For a time the correspondence and papers on geographical subjects were filed separately, under the special orders of the Secretary of State in Council, but on the 1st January 1879, other arrangements were made and the geographical and kindred papers were intermingled with those on all the other subjects, such as commerce, statistics, sanitation, &c., assigned to the new department. The subsequent history of the geographical work of the India Office has thus been merged with that of other subjects, and becomes a matter of great difficulty to trace, while the loss of Mr. Markham undoubtedly put an end to a good deal of projected work which the geographical staff would have helped to bring to completion. In 1879, Mr. Waterfield was created Financial Secretary, and Mr. W. G. Pedder, of the Bombay Civil Service, was appointed to the secretaryship of the Revenue Department, with which the old Statistics and Commerce Department, carrying with it the geographical business of the Office, was amalgamated. The geographical work by a natural process of gravitation thus came under the control of the Revenue Department with which it undoubtedly has an increasing affinity. For now that the principal triangulation, and the first rough topographical survey of India are practically complete, such fresh surveys as are required (apart from the trans-frontier operations) are mainly for revenue purposes, a need which the gradual extension of cultivation tends still further to enhance. The following year saw the transfer of the author to the Home Office in the capacity of Assistant Private Secretary to the Secretary of State for Home Affairs, and the special care of Indian geographical matters practically devolved upon Mr. Trelawney Saunders until 1885, when the return of the present writer to the India Office after five years' service in the Home Office led to further departmental changes, Mr. Saunders retiring on a pension. Mr. Saunders had done much useful service in the cause of geography, both before and after his entry into the India Office. Endowed with strong geographical instincts and tastes he was appointed in 1854 curator to the Royal Geographical Society, and also acted for a time as Librarian to that body. In 1857 he joined Mr. Stanford's establishment (originally his own house), and here he edited the useful series of school maps issued

by the firm, as well as supervised the construction of a series of Library maps of the great divisions of the globe, designed by Alexander Keith Johnston. He also designed and superintended the construction of the first detailed plan of London on the 6-inch scale, and assisted in editing the series of Biblical maps in Dr. Smith's Ancient Atlas. During his service in the India Office he produced a large number of maps, which have served as useful models of cartography for the native draughtsmen and lithographers of the Surveyor-General's Office at Calcutta. Foremost among these may be mentioned the excellent maps of the Haidarabad Circars in continuation of the series commenced by Mr. Walker, and the elaborate and valuable sets of maps prepared to illustrate the Moral and Material Progress Reports of 1871–72, 1872-73, and 1881-82. Mr. Saunders was also the author of "A Sketch of the Mountains and River Basins of India" and of the greater part of the General Catalogue of the Geographical Collection of the India Office. The elaborate geographical arrangement of the catalogue was entirely Mr. Saunders' creation.

In 1885 the Geographical Branch underwent a further change. The appointment held by Mr. Trelawney Saunders was abolished, and the present writer was placed in charge of the Geographical business, under the control of the Registrar, the correspondence, &c. being transacted under the general supervision of the Library Committee. Thus in eight years the geographical work came under the successive control of four different committees in the India Office. This, however, is a change similar to that which the geographical departments of most countries have had to undergo. The English Ordnance Survey was originally placed under the old Board of Ordnance, then under the War Office, and has since been transferred, first to the Office of Works, and now to the Agricultural Department. In India, the Survey Department has oscillated in like fashion between the Home and Revenue Departments. The fact is, that surveys (apart from revenue surveys), while supplying the basis of statistics for all, have no special and inherent connexion with any one particular department. At the same time, the work, though important, is limited in quantity, so it has always been necessary to place it under the wing of some larger department.

There is ample scope for its future usefulness, and in the Record Department there is every hope that the traditions of its short but active and profitable past will be not unworthily sustained.

APPENDIX I.

RETURN showing the NUMBER and VALUE of the SCIENTIFIC INSTRUMENTS and APPLIANCES provided for the VARIOUS SERVICES in INDIA and examined at the INDIA STORE DEPÔT, LONDON, from January 1887 to January 1890.

Description of Instrument.	Value. £	s.	d.
Accumulators	29	9	6
Agates	39	18	0
Air-pump	2	10	0
Altazimuth	40	0	0
Ammeters	21	0	0
Anthropometric apparatus	11	1	0
Apparatus, primer and relay	429	0	0
Apparatus, circuit closing	478	0	0
Anemometer	251	0	0
Anemograph	85	0	0
Apparatus for liquefaction of gases	12	8	0
Apparatus for interference of sound	1	0	0
Apparatus for water analysis	46	9	10
Apparatus to illustrate Ayrton's practical electricity	200	18	0
Apparatus, electric light	2,332	10	0
Arithmometers	75	0	0
Astronomical clock	70	0	0
Apparatus, submarine mining, various	562	16	9
Balances, weighing, various	532	0	0
Balances, electrical	210	0	0
Barlow lens	2	15	0
Bars, standard	15	0	0
Barometers, aneroid	428	3	11
Barometers, mercurial	693	11	0
Barographs, repaired	6	5	0
Batteries, voltaic, various	515	8	1
Bells, alarum	10	12	0
Binoculars, various	512	10	10
Boards, drawing	14	10	0
Boards, sketching	45	0	0
Bubble tester	20	0	0
Cabinets, chemical	858	0	0
Cables, electric, various	2,261	19	2
Calliper's micrometer	18	0	0
Cards for compasses, various	9	1	6
Carbon plates	514	11	0
Cases, sketching	64	15	0

Description of Instrument.	Value.		
	£	s.	d.
Cathetometers	58	0	0
Chartometer	2	5	0
Chains, measuring	41	4	0
Chronometers	224	0	0
Chronomicrometers	108	0	0
Chronographs	122	2	6
Clocks	135	15	0
Collimators	100	0	0
Comparing apparatus for standard measures	75	0	0
Combination boxes	34	0	0
Compasses, drawing, various	389	0	0
Compasses, magnetic	107	14	6
Compasses, prismatic	376	15	6
Compass, liquid	77	0	0
Compass, subtense	372	0	0
Clinometers	106	18	0
Core for telegraph cables	15,445	0	0
Cross staves	7	8	0
Curve ranger	12	0	0
Curves, various	59	0	0
Carbons for Jablochkoff lamps	331	18	0
Dioptric lights for lighthouses and ports	6,115	0	0
Dip needles		—	
Dynamo machines	24	15	0
Dynamo exploders	28	10	0
Dynamometers	2	15	0
Educational apparatus, Riggs'	138	13	1
Electric bells	10	0	0
Electrometers	19	18	0
Electro-magnetic and galvanic machines	469	8	6
Engine counters	9	7	0
Exploders	8	0	0
Eye pieces for theodolites and levels	72	10	0
Fault finder, telegraphic	57	0	0
Field cable, Siemens'	918	0	0
Galvanometers, various	320	18	0
Gauges, pressure and vacuum	306	14	0
Gauging instruments	39	12	6
Gauges, standard	12	12	0
Glass spirit bubbles	261	10	0
Glasses for heliotropes	30	13	5
Glasses, object	36	15	0
Glasses, tracing	4	14	6
Glasses, reading	30	12	6
Globes	6	12	4
Goniometers	17	10	0

Description of Instrument.	£	s.	d.
Heliographs	130	4	0
Heliostat. with block	5	10	0
Hydrometers, various	762	0	0
Hygrometers	19	0	0
Hypsometers	24	0	0
Indicators, Richard's steam engine	213	10	3
Ink writers, telegraphic	950	0	0
Instruments, mathematical drawing, in cases	1,295	0	0
Instruments, vibrating call signal	10	0	0
Instrument, telegraph, double and single current	282	0	0
Insulators, various	15,588	12	11
Insulating stand	0	11	0
Integrators	17	0	0
Keys, telegraphic Keys, firing Keys, reversing, Thomson's	7	14	6
Lactometers	3	12	0
Lamps, referring, &c.	17	1	0
Lamps, miners' surveying	11	0	0
Lamps, electric incandescent	545	7	0
Lathes	278	0	0
Lenses for eye-pieces	118	19	6
Lens, rapid rectilinear photographic	9	0	0
Levels, astronomical	15	0	0
Levelling instruments, reversible	4,416	0	0
Levels, reflecting	112	8	0
Levels, spirit block	35	0	0
Levels, striding	24	0	0
Machine, drilling	35	0	0
Magnets for relays	40	0	0
Magneto-inductor bridge	16	10	0
Meters, air	8	8	0
Microscopes, various	216	19	0
Mirrors for sextants	32	14	6
Mirrors for heliographs	70	4	4
Mines, submarine	2,227	14	0
Miners' dial	17	10	0
Micrometers	12	4	0
Nickel anodes	4	18	0
Observing chair	23	5	0
Observatory dome	250	0	0
Ophthalmic test glasses	25	4	0

Description of Instrument.	Value.		
	£	s.	d.
Optical squares	6	6	0
Optical bench	8	0	0
Optometer, Tweedy's	6	7	6
Pens, drawing	29	16	0
Pentagraphs	292	10	0
Photo-micrographic apparatus	35	3	0
Physical apparatus, various	1,714	10	0
Plane-tables	128	0	0
Planimeters	372	19	6
Polariscopes	3	5	0
Protractors, various	496	4	0
Pyrometers, various	29	16	0
Pitch compound for cables, telegraph	560	13	0
Rain gauges	113	13	6
Range finders, various	519	5	0
Relays	275	7	0
Resistance coils	53	10	0
Rulers, parallel, various	615	4	6
Rules, boxwood	37	13	0
Rules, flat, various	488	15	4
Revolution indicator, Buss's	21	0	0
Sand glasses	30	0	0
Scales, various	793	2	6
Sectors	3	7	0
Set squares, various	93	5	7
Sextants, various	105	10	0
Slide rules, various	16	11	0
Slopes and batters	2	5	0
Sounders, telegraph	211	1	0
Speedometers	8	12	6
Spectroscopes	52	11	0
Spherometer	8	18	6
Stadiometers	97	7	6
Station pointers	67	10	0
Standard yard measures	45	0	0
Stencil plates	24	7	10
Storm glass	0	6	0
Straight edges	176	15	0
Stop watches	36	0	0
Stills	58	9	0
Sundials	46	0	0
Switches, battery	2	3	0
Serving tape for cables, telegraph	3,088	10	0
Tachometer	31	10	0
Tapes, measuring, various	1,550	15	3
Telemeters	14	17	0

Description of Instrument.				Value.		
				£	s.	d.
Telephones, various				83	7	9
Tell-tale apparatus				17	3	0
Telescopes, various				968	7	0
Tellurions				6	5	0
Thermometers, various				1,116	19	9
Theodolites, various				8,657	0	0
T squares				29	3	6
Urinometers				228	5	0
Water meters				48	2	8
Weights, assay				14	2	6
Weights, troy, avoirdupois, and tola standards				81	0	0
Zenith telescope				90	0	0
Zinc rods for batteries				42	8	8
	£	s.	d.			
Miscellaneous apparatus not included under any of the above headings	3,245	18	10			
	2,070	10	6			
				5,316	9	4
Total (January 1887–January 1890)				94,728	9	7

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